The cosmology of Cosmological Relativity:
the expansion history from causal reassignment on a de Sitter background, the cosmogenesis branch point, and the scalar perturbation sector

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Abstract

Cosmological Relativity (CR) obtains the observed cosmological expansion by a causal reassignment on a de Sitter background at the cosmogenesis branch point, with the Einstein field equations unchanged. This paper develops that cosmology and completes it with its scalar perturbation sector. The reassignment selects the Nariai member [36] of Schwarzschild–de Sitter, whose proper frame is a homogeneous, observationally isotropic, *non-synchronous* cosmology with areal radius $r(\tilde{\tau}) \propto \sinh^{2/3}$—exactly the flat-ΛCDM scale factor—its rate fixed by the cosmological constant alone, with radiation and matter inherited content read off the cosmic clock rather than terms that source the expansion. The cosmic beginning is the branch point $r = 0$—a genuine curvature singularity of the SdS metric read over the r-chart [35], and *not* a singularity of the underlying substrate, whose throat is the defining constant α; the divergence of the r-chart invariants there is the areal coordinate degenerating; the constant-proper-time slices are exactly Euclidean ($\Omega_k = 0$) while the cosmological layers are a closed S^3—spatial curvature and dark energy one Λ read on two slicings. The acoustic scale and the apparent Hubble tension resolve as consequences of a rate fixed by the substrate's geometry: there is no second H_0 to reconcile, and the scale is met at the directly measured H_0 by a single inherited datum, $\rho_r/\rho_m \approx 2$—a one-parameter accommodation, the structural analogue of the baryon-to-photon ratio. The light-element composition is produced on the same footing: the infalling matter heats above the deuterium bottleneck and re-expands through it, so the cooling leg is a standard big-bang nucleosynthesis fixing the composition with the inherited baryon-to-photon ratio η—a second boundary datum of the same handover, distinct from the radiation amplitude ρ_r/ρ_m that sets the scale. Helium-4 and deuterium sit at their observed values—the freeze-out temperature the data demands being the bottleneck the standard rate delivers, un-tuned; the near-zero metallicity of the oldest systems follows from the handover; and because the run is standard, lithium-7 carries the standard threefold over-prediction, the lithium problem shared with flat ΛCDM rather than dissolved.

On this cosmology the primordial scalar spectrum *factorizes.* The de Sitter substrate *determines* its structure—the geometric coherence of the acoustic phases on the null boundary (not a super-horizon freeze-out), the classical non-vacuum character of the fluctuations (the substrate vacuum lies some 10^{113} below the observed A_s), the throat's isotropization, a parameter-free low-multipole discreteness floor, and the faithful transmission of the spectral shape—while the progenitor collapse *supplies* its content, the amplitude A_s and tilt n_s, inherited as boundary data exactly as flat ΛCDM inherits the baryon-to-photon ratio. *The transmission is now supported by a mechanism rather than by the absence of a scale alone* (§3): on the contracting leg aH grows without bound as the branch point is approached, so the comoving horizon shrinks to zero and every mode *exits* it and freezes before the crossing; the imaginary-time segment's Euclidean kernel damps oscillatory content and has nothing to act on in a frozen mode, so amplitude and tilt cross unaltered while the collapse-leg acoustic phase does not—which the observed peak positions independently require, excluding a transmitted leg phase by a factor of 21–41 in the required distance [9].

The decisive result is a *transmission dichotomy*: a non-degenerate horizon's exponential near-horizon approach imprints a scale-invariant spectrum (the inflationary de Sitter-horizon

mechanism), whereas the degenerate Nariai member's power-law, scale-free approach to the branch point is *argued* to transmit the progenitor spectrum unaltered—an argument from the absence of an imprinted scale, not a computed transfer—so CR has no inflationary scale-invariant attractor, no consistency relation, and no substrate-sourced primordial B-modes.

Because the distance slicing is flat, the discrete closed-S^3 source projects through the flat transfer to a parameter-free low-multipole deficit ($\ell \lesssim 8$)—mild, and on a genuine Boltzmann transfer a dip whose *minimum falls at* $\ell = 4$ (≈ 0.36 of the ΛCDM expectation there, ≈ 0.47 and 0.41 at $\ell = 2$ and 3; the shape cross-validated between two independent transfers, which agree on the location and the recovery and differ on the depth by up to a factor of two at $\ell = 3$ and 4), and non-discriminating: it starves $\ell = 2$ and $\ell = 3$ together and so matches neither the sharp observed quadrupole-only dip nor the near-ΛCDM octopole, sitting consistent with ΛCDM within the lowest multipoles' cosmic variance.

Taken together, these results carry a reckoning the paper draws in full: what flat ΛCDM assembles from added, tunable apparatus—inflation for the horizon, flatness, coherence, and near-scale-invariance, a dark-energy component for the late-time acceleration, added early-universe physics for the tensions—this cosmology recovers from the cosmological constant alone, each feature required by structure already present rather than produced by a sector introduced to yield it. By the economy of assumption that distinguishes a required structure from a merely permitted one, that comparison is settled now, on the theory-choice axis, in this cosmology's favour; and the data axis has now moved with it, from even toward favoured: the Hubble tension is resolved across the low-redshift distance ladder and not the acoustic angle alone—a rate whose two parameters are geometric carries H_0 out of the baryon-acoustic observables, which fit at the directly measured H_0 where ΛCDM cannot—on the SDSS DR12 consensus and, at the current state of the art, the DESI DR2 dataset (thirteen measurements across seven tracers) at $\chi^2/\text{dof} \simeq 1$ with the single CMB-calibrated $\Omega_m \simeq 0.31$—and the light-element abundances are confirmed within 1σ at the microwave-background baryon density (the cosmogenesis paper [18]).

The cosmology is thus empirically favoured, not merely more economical, with its exposed edges named: a CR-specific signature in the diffusion *scale* (the same geometric rate that dissolves the Hubble tension enlarges the Silk scale [26])—a real, computed effect of definite sign, non-reabsorbable by the baryon density and independent of H_0, whose *magnitude* moves with the fitted onset redshift (computed at 8.2% and at 14.0% at two onsets differing by half a per cent) and is pinned only when that fit is, but whose observable consequence for the high-ℓ power is entangled with the acoustic transfer at those multipoles (whether CR's high-ℓ peaks track ΛCDM's, verified only through the third peak) and so genuinely open, neither a demonstrated tension nor a wash —though now located: the signature is a Gaussian in ℓ and a tilt a power law, so a refit absorbs it only window-locally, and what a joint fit meets is a shape residual rather than a shifted tilt; and the full-spectrum likelihood (the low multipoles being a mild, non-discriminating deficit rather than a sharp edge either way).

We mark maturity throughout. *Established*: the cosmological derivation, the transmission dichotomy, the amplitude floor, the throat, the flat slice, the flat-projection transfer, the data confrontation, and the time-reversal driving equality that carries the peak *heights* (the driven acoustic amplitude flat ΛCDM's exactly, on the standard inherited plasma the abundance comparison confirms). *Argued*: the coherence mechanism.

Run, and returning a disagreement rather than a confirmation: the end-to-end branch-point-to-recombination transfer, rebuilt as the standard line-of-sight integral across a visibility of finite width and validated to 0.16% on the control's first peak, then carried through to this construction's arm—the height pattern tracks and the phase does not. *Open*: the damping-scale signature's observable consequence, the *derivation*—as against the measurement—of A_s, n_s, and the inherited datum the composition is run on, and the diagnosis of the phase offset the transfer exposed. *The cosmology carries one fitted parameter and its status should be stated plainly*: z_{onset}, the redshift at which the expanding-phase plasma begins, which is the lower limit of the sound-horizon integral, set by where the expanding-phase plasma begins rather than by a radiation era the geometric rate does not carry. It is fitted to the acoustic angle at the *directly* measured H_0 and lands at $z_{\text{onset}} \approx 6.8 \times 10^3$, $T_{\text{onset}} \approx 1.6\,\text{eV}$, near $\rho_r/\rho_m \approx 2$. *It is not a knob for the H_0 tension*: r_{s} and D_M carry the stacking rate's common H_0, which therefore scales out of their ratio, so θ_* is fixed by the

offset x_0 alone (equivalently by $\Omega_m = 2/(x_0^3+2)$) and the same z_{onset} meets the scale at every H_0 across the range—it does not move between them. *Matter–radiation equality is then a consequence and a check, not an input*—$1+z_{\text{eq}} = 3399$, exactly half the onset, where the fitted Ω_m and the Hubble constant reproduce the microwave-background-inferred physical matter density (near $H_0 \simeq 68$); read at the directly measured H_0 instead, the same z_{onset} gives $\rho_r/\rho_m = 1.71$, so the datum is an order-unity band and not a determined number; and z_{onset} is a redshift on the expanding leg, not the branch point, which no finite cosmic-time layer reaches. The substrate's single Λ is shown to govern both the global expansion and, per structure, the local scale at which structure resists it—the Hubble–Eddington radius—one constant read at two ranges.

1 Introduction: the cosmological theory and its scalar perturbation sector

Cosmological Relativity (CR) recovers the flat-ΛCDM expansion history by a causal reassignment on a de Sitter background at the cosmogenesis branch point: the expansion rate is fixed by the cosmological constant alone, radiation carries no term in it, and the present matter density is a reading of the cosmic epoch rather than an independent quantity [9, 11]. The cosmic beginning is the branch point $r = 0$—a genuine curvature singularity of the SdS metric read over the r-chart, and *not* a singularity of the substrate, whose throat is the defining constant α, and the construction makes the constant-proper-time slices exactly flat while the cosmological layers are a closed S^3. This paper develops that cosmological theory in the form its observational tests require (§2) and completes it with the scalar perturbation sector the framework paper's outlook named open—"perturbations within the Schwarzschild–de Sitter representation"—the primordial density perturbations and their imprint on the microwave background (§§4–8), closing on the open frontier the construction sets up (§10). Across these sections one comparison recurs and is drawn together at the close (§9): the causal contact, flatness, coherence, isotropy, and near-scale-invariance that the standard picture obtains from an added, tunable inflationary sector are here read off structure already present and fixed by Λ alone—an economy-of-assumption difference the paper argues is decidable now, on the theory-choice axis where it falls to this cosmology—and the data axis has now moved with it, the Hubble tension resolved across the low-redshift distance ladder and the light-element abundances confirmed against the data (§2.4), so the reading is empirically favoured and not merely more economical, its remaining exposed edges the damping-*scale* signature—a computed, non-reabsorbable CR-specific effect of definite sign and z_{onset}-dependent magnitude whose observable consequence awaits the high-ℓ acoustic transfer, genuinely open—and the full-spectrum likelihood, the low multipoles a mild, non-discriminating deficit rather than a sharp edge either way. The companion dynamics paper develops the perturbation sector's *tensor* half—the propagating graviton as the leaf's shear, a massless de Sitter mode on the cosmic foliation [10]; the scalar half is here.

The result is organized by one thesis, which we state at the outset because it controls everything below.

> *The CR primordial scalar spectrum factorizes: the de Sitter substrate geometry determines its structure, the progenitor collapse supplies its content, and the branch point's null geometry assigns each its job.*

Substrate-determined, and developed here: the coherence of the acoustic phases (§4); the classical, non-vacuum character of the fluctuations (§5); the isotropizing throat (§6); a parameter-free low-multipole discreteness floor (§7); and the faithful transmission of the spectral shape (§8). Progenitor-supplied, and inherited rather than derived: the amplitude A_s and tilt n_s. This is the same division of labour by which flat ΛCDM carries the baryon-to-photon ratio η as a measured datum from a baryogenesis it does not model; this cosmology carries one such datum—the onset redshift $z_{\rm onset}$, equivalently the radiation amplitude $\rho_r/\rho_m \approx 2$ *at onset* that calibrates the acoustic scale, fixed by the hot handover of the progenitor collapse—and the transmission result of §8 routes A_s and n_s through the *same* handover. There is one boundary-condition supplier, not two.

A word on what is settled before the spectrum. The acoustic *scale* (the peak spacing) and the apparent Hubble tension are resolved in the cosmological development above (§2.3): the tension dissolves as a consequence of the geometric rate, and the scale is met at the directly measured H_0 by the single measured parameter $\rho_r/\rho_m \approx 2$, with the sound speed the ordinary baryon-loaded value of pressureless branch-point matter. *The sky's own side of that comparison is measured here rather than quoted. Locating the acoustic peaks of the Planck 2018* `plik_lite` *binned TT spectrum [23] by parabolic fit to each hump above* $\ell = 100$ *returns* $\ell = 220.4$, 537.7, 817.3 *and* 1123.9, *which reproduce the standard quoted values to better than one per cent without having been fitted to them. Fitting* $\ell_n = \ell_A(n+\phi/\pi)$ *to the first three gives the sky* $\phi/\pi = -0.2404$ *against* -0.2361 *for a* Λ*CDM control measured by the identical procedure—an offset of* 0.0043*, so the control stands in for the sky on this quantity to within seven parts in a thousand.* The move has a name and the name is worth stating, because it is what licenses the comparison*: this is* matched-procedure differencing*—the control is passed through the identical extraction, so whatever bias the procedure itself carries appears in both arms and cancels in their difference, and what survives is attributable to the physics rather than to the instrument.* The same discipline governs every control in this sector*: a residual is credited against CR only once the control, run through the same machinery, has been shown not to produce it.* What this construction's own arm returns against that measured comparison is reported in §4.7*, the two-arm transfer being validated on the control and carried to convergence on both arms.* These are settled there and are not reopened in the perturbation sector; in particular, the standard radiation-governed sound horizon laid on this cosmology's rate is a calculation belonging to neither framework, and any "tension" it produces is an artifact, not a CR result. What is genuinely downstream is the *spectrum*—the peak heights, carried below by the time-reversal driving equality (§4), and the full oscillating-medium transfer, still open—which is where this paper's substance lives.

The register is the programme's [14, 9]: the field equations are Einstein's, unchanged; the existing object is the evolving three-dimensional layer; "the substrate determines" and "the branch point transmits" are statements about a real geometry and its real boundary [17, 16], not about a modification of the dynamics.

2 The cosmological theory the perturbations complete

This paper develops the cosmology of Cosmological Relativity from first principles and carries it to its empirical confrontation, completing it with the scalar perturbation sector. It takes from the companion framework paper [9] the *general* primitives—the layered ontology, the projection principle, and the representational freedom by which one fixed manifold admits distinct Lorentzian metrics—together with the Null–Boundary Correspondence theorem, the structural result (grounded in the metric-singularity causal structure of gravitational collapse [4]) that a collapse event-of-events and a de Sitter cosmic-entry slice are one ontological layer under two causal assignments. The cosmology proper is built here: the causal reassignment that selects the Nariai member, the proper-frame expansion law, the branch point at which the collapse leg becomes the expansion leg—the beginning, reached a lap on from the horizon the Correspondence anchors—and the resolution of the apparent Hubble and acoustic tensions; the perturbation sector (§4–§8) is its completion.

2.1 The causal reassignment and the Nariai member

The vacuum solution of $R_{\mu\nu} = \Lambda g_{\mu\nu}$ with a localized source is Schwarzschild–de Sitter (SdS),

$$ds^2 = -\frac{r}{\frac{\Lambda}{3}r^3 + \frac{2GM}{c^2} - r}\,dr^2 + \frac{\frac{\Lambda}{3}r^3 + \frac{2GM}{c^2} - r}{r}\,dt^2 + r^2 d\Omega^2, \tag{1}$$

whose areal radius r is timelike in the cosmological regime $\Lambda G^2M^2/c^4 \geq 1/9$. Building the cosmology, we reassign causal roles on the de Sitter substrate—a move licensed by the representational freedom of the framework, distinct Lorentzian metrics on one fixed manifold sharing its foliation [9]: the de Sitter null rulings whose causal sense matches a collapse horizon's generators are promoted to the timelike fundamental congruence, the at-rest comoving worldlines become the null photon congruence, and the foliation by expanding 3-spheres is preserved. This selects the *Nariai* member $\Lambda G^2M^2/c^4 = 1/9$, $M = c^2/(3\sqrt{\Lambda}G)$—the unique non-pivoting tilt, fixed by Λ alone—at which the two positive horizons merge at $r_N = \alpha/\sqrt{3}$, $\alpha = \sqrt{3/\Lambda}$ the de Sitter 3-sphere size (a scale distinct from the merged-horizon radius $\alpha/\sqrt{3}$ and from the areal-radius amplitude below; we keep the three apart throughout). The selection is geometric—the fixed point of the slicing curve's root-exchange involution, equivalently the limiting tangent orientation a collapse selects—not a fitted mass [5]. That the selection is moreover *unique* is a structural fact about the description groupoid rather than a fitting: the generic vantages fall into two-cycles of the involution, the Nariai member is its one fixed point, and the reassignment promoting a null direction to the fundamental congruence is forbidden at every generic vantage, so it selects Nariai and no other [6].

2.2 The proper-frame cosmology, derived

In the proper frame of the fundamental observers the SdS metric is a homogeneous, non-synchronous cosmology. The derivation [15] proceeds from (1) in five steps. (i) A timelike radial geodesic has a conserved energy E (the metric being independent of t); eliminating $dt/d\tau$ in the normalization $L = -1$ gives the radial equation $(dr/d\tau)^2 = E^2 - V_{\text{eff}}(r)$, with $V_{\text{eff}} = (r - 2GM/c^2 - \frac{\Lambda}{3}r^3)/r$. (ii) The fundamental congruence is the worldlines whose motion in r is produced purely by the field—those at rest exactly where $V_{\text{eff}} \equiv 1$ and the metric reduces to Minkowski—which is $E = 1$; this fixes the rest frame by the field rather than by stipulation, *and it is worth saying where that locus is*: $V_{\text{eff}} = 1$ is $r^3 = -2GM\alpha^2/c^2$, so the rest frame is defined at $r = -(6GM/c^2\Lambda)^{1/3}$—a *negative* areal radius, on the conjugate branch of the lap, between the progenitor's horizon and the branch point [9]. *In the original derivation that locus had to be carried as a formal one*—"a negative mathematical abstraction that lies beyond a singularity at $r = 0$... simply a matter of algebraic consistency" [2, App.]—*and the construction has since made it a place.* The same locus fixes the sign, since $t = \tau$ there if and only if $E = +1$. (iii) With $E = 1$, integrating the radial equation gives, along one worldline, $r(\tau) \propto \sinh^{2/3}(\frac{3}{2}\sqrt{\Lambda c^2/3}\,\tau)$. *That this integration closes at all is a second thing the same condition buys.* Writing the radial equation as $(\mathrm{d}r/\mathrm{d}\tau)^2 = 2GM/c^2r + r^2/\alpha^2 - k$ with $k = 1 - E^2$, the quadrature $\int \mathrm{d}r/\sqrt{\cdot}$ is elementary at $k = 0$—it is $\frac{2\alpha}{3}\operatorname{arcsinh}\big(r^{3/2}/\sqrt{2GM\alpha^2/c^2}\big)$, which inverts to the $\sinh^{2/3}$ above—while for $k \neq 0$ the substitution $r = u^2$ carries it to a sextic under the root and it is not elementary. *So $E = 1$ fixes the rest frame by the field and, by the same stroke, is the one non-degenerate energy at which the cosmology integrates in closed form*; the only other elementary cases are the degenerate ones, $\Lambda = 0$ giving the dust cycloid and $M = 0$ giving pure de Sitter[L14]. (iv) Labelling the congruence by a comoving coordinate χ through the integration constant $r(0)$, the areal radius across the congruence depends on τ, χ only through their sum, $r(\tau, \chi) = r(\tau + \chi)$, with $\partial_\chi r = \partial_\tau r$. (v) Fixing the transformation $t(\tau, \chi)$ by requiring the comoving coordinate orthogonal to proper time, $g_{\chi\tau} = 0$, forces the integration function to be χ itself, and the remaining components follow ($g_{\tau\tau} = -1$, $g_{\chi\chi} = (\partial_\chi r)^2$). The result is the

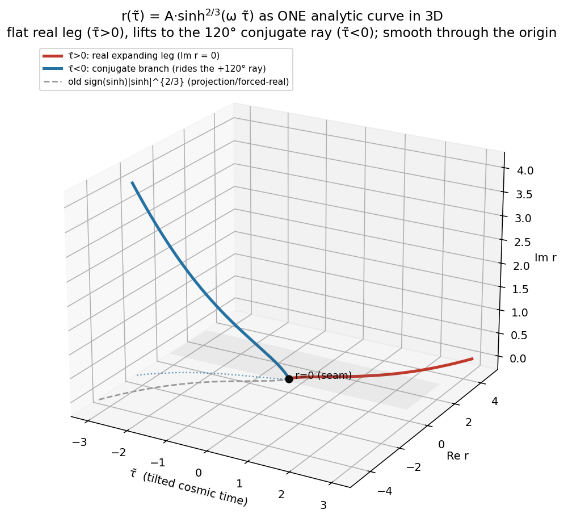

Figure 1: The scale factor (3) as one analytic curve $r(\tilde{\tau})$ in $(\tilde{\tau}, \mathrm{Re}\, r, \mathrm{Im}\, r)$. The expanding cosmology is the real leg $\tilde{\tau} > 0$, lying in the real plane; the branch point $\tilde{\tau} = 0$, $r \to 0$—*not* a seam—is where the curve leaves the real plane onto a conjugate branch at constant phase $2\pi/3$ for $\tilde{\tau} < 0$. The beginning is this analytic branch point, not a real $r = 0$ boundary. Forcing r real (dashed) projects the conjugate branch onto the negative axis and manufactures a cusp the smooth curve does not carry.

proper-frame line element

$$ds^2 = -d\tau^2 + (\partial_\chi r)^2 \, d\chi^2 + r^2 d\Omega^2, \tag{2}$$

with cosmic time $\tilde{\tau} \equiv \tau + \chi$ (by Weyl's principle the congruence issues from a common origin and the constant-cosmic-time slices are those of constant $\tilde{\tau}$), areal radius

$$r(\tilde{\tau}) = \left(\frac{6GM}{\Lambda c^2}\right)^{1/3} \sinh^{2/3}\left(\tfrac{3}{2}\sqrt{\tfrac{\Lambda c^2}{3}}\, \tilde{\tau}\right), \tag{3}$$

and redshift $1 + z = r(\tilde{\tau}_0)/r(\tilde{\tau}_e)$. The constant-$\tilde{\tau}$ slices sit at 45° to the fundamental rest frame: the cosmology is homogeneous and observationally isotropic, yet *non-synchronous*—the constant-τ slices are exactly Euclidean (§7) but are not the cosmological ones. Of the FLRW kinematic assumptions—(i) a geodesic congruence, (ii) hypersurface orthogonality, (iii) homogeneity, (iv) isotropy—this construction keeps (i) and drops (ii); Lemaître's reading [29] of the Euclidean slices as "space ejected from $r = 0$" is causally incoherent and is not the physics. Equation (3) is moreover a single analytic function of $\tilde{\tau}$ (Fig. 1): the expanding cosmology is its real branch $\tilde{\tau} > 0$, and the cosmogenesis *branch point* at $\tilde{\tau} = 0$, where $r \to 0$, is the branch point of the scale factor rather than a real $r = 0$ boundary—and it is *not* a seam: the seams are the two unit-speed loci of the lap, $r = -2\alpha/\sqrt{3}$ and $r = +\alpha/\sqrt{3}$ [9], and $r = 0$ lies strictly between them, at the close of the lift—the analytic counterpart of the beginning at the branch point, where the substrate's curvature stays finite while the geometry read over the r-chart diverges [4], and the cosmological reading of the slicing curve's closed lap—the *cosmogenetic bead* the framework establishes as one closed object [5, 9], of which this scale factor's real branch $\tilde{\tau} > 0$ is the expansion leg and its analytic continuation the prior universe's collapse—on which $r = 0$ is a branch point and not a barrier, the substrate smooth across the locus the chart so labels [5].

2.3 Exact recovery of flat ΛCDM, and the amplitude fixed by Λ

What fixes this rate is worth stating before what it recovers, and the count is smaller than it looks. The rate this cosmology computes on is set by the substrate's geometry and by nothing else. *It has one parameter*—the substrate curvature radius $\alpha = \sqrt{3/\Lambda}$, an invariant length—*and one epoch.* At the Nariai member the mass is no longer free (5), so the amplitude and the rate of the expansion law are both set by Λ and the scale factor is one function of it; what remains is where the present sits on that one curve. *The quantity x_0 carries that*: it is the present areal radius in units of the Nariai radius, $x_0 = r(\tilde{\tau}_0)/r_N$, and since $r_N = \alpha/\sqrt{3}$ is fixed by Λ the number is a clock reading and not a second geometric datum[P15R7]. *The geometry's own offset is fixed twice over*: it is the double root of the horizon cubic at the Nariai mass, and it is the constant ledger's $2M = \alpha\big((r_0/\alpha) - (r_0/\alpha)^3\big)$ with M at that mass [5, 17]—*so "the offset" names the unit, and x_0 the reading taken against it. So the ratio it fixes is a reading of cosmic epoch*, which is what (7) says of the density ratio directly. *Neither the parameter nor the epoch is a content of the universe*:

$$c^2H^2(z) \;=\; \frac{c^2}{\alpha^2}\Big(1 + \frac{2(1+z)^3}{x_0^3}\Big). \tag{4}$$

The offset is measured directly and calibration-free—$z_{\rm acc} = x_0 - 1$, (11) below—without a distance ladder, without the microwave background and without any density. *What the rate is a rate of is the stacking of the foliation*, and content does not enter it: radiation is absent from the slicing operator's vacuum kernel, requiring $m'(r) \neq 0$, a bend of the cut; and the second term is the offset itself rather than a density supplied by hand [7, 9].

The familiar cosmological form is accordingly a coincidence of form, and saying so is the substance of this subsection. Written in the fitted pair the same rate reads $H^2 = H_0^2\big[\Omega_m(1+z)^3 + \Omega_\Lambda\big]$, with $\Omega_m = 2/(x_0^3+2)$ and $\Omega_\Lambda = x_0^3/(x_0^3+2)$ following identically—*a translation between parameter sets, and not a decomposition into components.* In the standard reading cosmic time is orthogonal to the three-dimensional world and the expansion is driven: by initial conditions, and by whatever densities obtain at each moment, through the field equations. Here it is read off a fixed background whose foliation is *not* orthogonal to the proper time of observers at rest, so that such observers move through the universe over cosmic time in a geometrically fixed manner. *The two readings agree on the function and share nothing beneath it.*

Where the field equations act is the leaf, and they act there in full. All stress-energy gravitates, by the ordinary Friedmann readout of the self-gravitating congruence; the perturbations, the plasma's sound horizon and its diffusion length are processes running *in* the content and take that rate, while a comoving separation read across leaves takes the stacking rate (§2.2). *What the layered framework keeps apart is not two physics but one physics and its projection*: a quantity is computed on the level it belongs to, carried on the layer and then projected.

Equation (3) is exactly the flat-ΛCDM scale factor. At Nariai the mass is no longer free, and the amplitude becomes a pure Λ-length,

$$\left(\frac{6GM}{\Lambda c^2}\right)^{1/3} = \frac{2^{1/3}}{\sqrt{\Lambda}}, \tag{5}$$

so both factors of the expansion law are set by Λ[P15R32]: the rate $\frac{1}{2}\sqrt{3\Lambda}\,c$ is the standard late-time rate and the amplitude is the third Λ-scale (distinct from α and $\alpha/\sqrt{3}$). The Friedmann equation the $\sinh^{2/3}$ law satisfies,

$$H^2 = \frac{\Lambda c^2}{3}\coth^2\!\Big(\tfrac{1}{2}\sqrt{3\Lambda}\,c\,\tilde{\tau}\Big) = \tfrac{1}{3}\big(8\pi G\rho + \Lambda c^2\big), \tag{6}$$

makes the density ratio a clock[P15R32],

$$\frac{\Omega_m}{\Omega_\Lambda} = \operatorname{csch}^2\!\Big(\tfrac{1}{2}\sqrt{3\Lambda}\,c\,\tilde{\tau}\Big)\,, \tag{7}$$

so $\Omega_{m,0}$ records the cosmic epoch $\tilde{\tau}_0$ at which we observe rather than an independent density, and the coincidence problem becomes the observation that we exist at a time of order the geometry's single timescale. The densities are bookkeeping for one Λ-set geometry; *radiation, like matter, is inherited content read off that clock, not a term that sources the rate*, and there is no radiation-dominated era [11]. The objection that a perturbing radiation fluid "must gravitate and so alter the rate" is a category error against a construction that reads (6) leftward: the rate is set, and the fluid's energy is among the contents the set rate carries. The acoustic *scale* and the apparent Hubble tension resolve as consequences of this rate; this is developed next (§2.4).

2.4 The acoustic scale and the dissolved tensions

The two frameworks reproduce the late-time expansion identically and part in the early universe, where radiation carries no term in the rate (6). The apparent tensions of the standard model are consequences of that one structural fact.

The three levels, and which rate each quantity uses. The reading of every rate-bearing quantity below is fixed by locating it on one of three levels, which the geometry keeps apart and whose conflation is the standing error the layered framework names [9]. **(L1) The foliation stacking rate**: the Λ-set $\sinh^{2/3}$ law (6) read *leftward* in the sense the slicing paper fixes [7]—the cut is primary and ρ is the name of its bend, not its cause, the rate-side of the slicing operator's reading whose content-side is *matter is the bend of the cut* [7]—the layer's own geometric expansion, set by α and the offset x_0, and *empirically forced* rather than modelled: the microwave-redshift isotropy floor forces uniform expansion to some three orders of magnitude, so a matter-tracking (radiation-sourced) rate is already excluded by data [11].

This is what the observable cosmology rides at *every* epoch, the branch point included: it is the rate the foliation stacks at, not a regime that begins somewhere. **(L2) The leaf-level local dynamics**: the expansion scalar of a self-gravitating congruence, the ordinary Friedmann read-out $\mathcal{H}^2 = \frac{8\pi G}{3}\rho_{\rm tot} + \frac{\Lambda}{3}$ with radiation gravitating normally—the valid phenomenological reading of general relativity on the progenitor's collapse excursion, where nucleosynthesis runs [18]; it is the same single E=1 geodesic read *inward* as dust collapse that L1 reads outward as cosmology [7, 4]. **(L3) The $E = 1$ projection**: the reassigned shadow the observer reads, through which an L1 or L2 quantity appears as distance and redshift—the Projection Principle of the framework paper, its geometric origin the *second ruling* of the slicing (the synchronous space is the second ruling) [9, 7]; reading this appearance as the existent is precisely the naïve-realist collapse the epistemology forbids [12]. The decision rule is structural, not a choice: a self-gravitating local excursion runs on L2, diffuse content riding the global foliation on L1, and every observable is an L1 or L2 quantity seen through L3; and *there is no L1/L2 boundary in time.* The distinction is kinematic and holds at every epoch: the vacuum kernel of the slicing operator is the SdS family exactly—Λ and the cut's offset $2M$, and no more [7]—so the stacking rate is $c^2 H^2_{\rm stack} = (c^2/\alpha^2)(1 + 2(1+z)^3/x_0^3)$, while radiation, requiring $m'(r) \neq 0$, is a *bend* of the cut and therefore content. The decomposition is exact, $H^2_{\rm leaf} = H^2_{\rm stack} + H_0^2\Omega_r(1+z)^4$: the two rates differ by the radiation term alone. A comoving separation read across leaves takes the stacking rate; a process running in the content—$r_{\rm s}$, r_D, recombination, the perturbations—takes the leaf's. The assignment looked temporal only because $\Omega_r(1+z)^4$ is negligible below $z \sim 10$ [9, 4]. Each mis-assignment is quantitatively fatal—the geometric L1 rate carried down into the nuclear window is $\sim$300× too slow, and the radiation-sourced L2 rate carried past the branch point radiation-pins $r_{\rm s}$ and re-manufactures the very tension this section dissolves [18]. Crucially L1 is the layer's own *ontological* expansion, not the L3 shadow: computing a process against the stacking rate is reading the geometry, not the appearance. Every rate-bearing quantity below carries its level, so the reading is settled by the geometry rather than defaulted to the synchronous machinery.

The Hubble tension. There is no second H_0 to reconcile. The late-time expansion is reproduced exactly, so the directly measured rate is the reading of the geometry, while the microwave background's lower inferred H_0 rests on a radiation-governed sound horizon $r_{\rm s}$ this construction does not share. The $\sim 5\sigma$ discrepancy is not two independent fits to be reconciled but the artefact of calibrating the acoustic scale with an early-universe sound horizon foreign to a geometrically fixed expansion.

The acoustic scale, to a one-parameter accommodation. Recombination is observable cosmology from the branch point onward, so its scales are L1: both the sound horizon r_s and the comoving distance D_M ride the foliation's stacking rate, and the observed angle $\theta_* = r_s/D_M$ is their L3 projection.

The robust ingredients are in hand: D_M is the standard observable, and $H(z)$ is the fixed $\sinh^{2/3}$ law (6) with radiation absent from the rate.

The sound horizon $r_s = \int_{z_{rec}}^{z_{onset}} (c_s/H)\,dz$—an L1 quantity whose baryon-loaded c_s is ordinary content microphysics but whose expansion H is the L1 rate—then depends on a single early-universe parameter, the redshift z_{onset} at which the expanding-phase plasma begins; the standard radiation-governed r_s is recovered only in the limit $z_{onset} \to \infty$ that a beginning at finite curvature forbids. *That clause carries more weight than its length suggests, and the sense of "finite curvature" in it should be the substrate's.*

The branch point is a locus at which the areal chart's invariants diverge—$r = 0$ is a genuine infinite-curvature locus of that chart—while the curvature of the manifold the cut is taken on is set by α everywhere, so the divergence is the areal coordinate degenerating and not a scale of the geometry [18, 17]. *Read the other way the accommodation would collapse*: a beginning at genuinely unbounded curvature places no finite floor under z_{onset}, the $z_{onset} \to \infty$ limit is reinstated, and the single datum ceases to be a datum at all. *The one-parameter accommodation therefore rests on the substrate reading of the branch point*, and a reader who took the areal divergence for the physics would find the parameter unconstrained. Taking c_s the ordinary baryon-loaded value—the matter at onset is pressureless, and the geometric throat ratio $\sqrt{3}$ does not set it—the measured acoustic scale is reproduced at the *directly* measured H_0 by a single z_{onset}, near $\rho_r/\rho_m \approx 2$ (about twice matter–radiation equality) and *independent of* H_0—the independence belonging to z_{onset} itself, and the ratio being that same quantity re-expressed, as §2.4 returns to below: r_s and D_M carry that rate's common factor H_0, which scales out of their ratio, so $\theta_* = r_s/D_M$ is fixed by the offset x_0 alone and the single z_{onset} that meets the scale is the same at every H_0 across the range—the datum cannot be a parameter tuned to reconcile two values of H_0, since it does not move between them. This is exactly where the standard rate parts: carrying radiation, it ties θ_* to H_0—the coupling that fixes the lower microwave-background value and stands in tension with the direct one—whereas a rate whose parameters are geometric decouples the scale from H_0, meeting it at the directly measured value with no second H_0 to reconcile. The beginning is well posed: the branch point—finite in the substrate's curvature, whatever the r-chart geometry does there (§2.2)—places the onset down the cooling branch, $T_{onset} \sim 1.6\,\text{eV}$ at $z_{onset} \sim 6.8 \times 10^3$, so a pre-recombination sound-travel interval exists and the integral $\int_{z_{rec}}^{z_{onset}}$ is well posed.

The inherited datum. The empirical forcing of the cosmic foliation bears on the rate, not the matter content—the matter density being the bend of the spatial cut [11, 7, 8]—so the radiation amplitude is measured content, not a quantity the geometry sets; the cold seam (Gibbons–Hawking temperature [32] $\sim 10^{-30}\,\text{K}$, some thirty orders below the onset) confirms there is no geometric source to set it instead. *One thing about that ratio should be said plainly before it is leaned on, because it is a unit and not a second datum.*

The quantities this cosmology actually uses are the epoch x_0 (equivalently $\Omega_m = 2/(x_0^3+2)$; *x_0 is the expansion read in units of the geometry's own fixed offset r_N, not the offset itself, which the Nariai condition fixes at $\alpha/\sqrt{3}$*), which the rate carries and the baryon-acoustic data fix; ω_b and ω_γ, which the sound speed carries and which are measured directly and framework-independently; and z_{onset}, the one fitted number.

The *physical* matter density $\omega_m = \Omega_m h^2$ enters none of them.

One thing about Ω_m is worth stating plainly, since the construction's matter sector invites the question. The dust the rate carries exceeds the baryons by about a factor of six, $\Omega_m \simeq 0.31$

against $\omega_b/h^2 \simeq 0.05$, so most of it is non-baryonic. *That is not a component this cosmology introduces, and it is not one it derives.* What the matter sector fixes is the number of families, their chirality and the S_3 relating them, and *nothing about their internal content* [19]; abundances are measured content throughout, the matter density being the bend of the spatial cut. So the non-baryonic fraction stands with η, A_s and n_s: inherited, not set by the geometry. *What the construction does supply is a place rather than an abundance.* Its correspondence with the Standard Model's content carries a right-handed neutrino as the sixteenth Weyl fermion of each generation, and fixes that state's place while fixing none of its couplings [19]; a species that is never thermalized contributes nothing to N_{eff}, so nucleosynthesis is untouched and no prediction is made or needed here. *The point of the paragraph is the division of labour*: a candidate the construction already contains, an abundance it does not claim, and no third thing wedged in between.

But ρ_r/ρ_m at onset is $\omega_r(1+z_{\text{onset}})/\omega_m$ and equality is $1+z_{\text{eq}} = \omega_m/\omega_r$, so both divide by that one quantity—and $\rho_r/\rho_m \approx 2$ is therefore not a second inherited number standing beside z_{onset} but z_{onset} itself, read in units of a density the construction does not determine. *The consequence is a stated H_0-dependence in the ratio and in nothing else*: with Ω_m held at its fitted value the ratio is 2.01 at $H_0 = 67.4$ and 1.71 at $H_0 = 73$, the two readings coinciding at $H_0 \simeq 68$ where $\Omega_m h^2$ reproduces the microwave-background-inferred $\omega_m = 0.143$. *What carries weight is what survives that*: z_{onset} does not move with H_0 at all, so it cannot be absorbing the tension; and the inherited amplitude, read at onset, is order unity—which is a statement about where the onset sits and *not* a contrast with η, as the withdrawal two paragraphs below sets out. *The factor of two is exact at $h \simeq 0.68$ and should be quoted as an order-unity band, not as a determined number* (receipt: `the_ratio_is_the_onset_in_imported_units.py`[P15R18]).

Thus $\rho_r/\rho_m \approx 2$ is the structural analogue of the baryon-to-photon ratio η: as flat ΛCDM carries η from a baryogenesis outside the model proper—measured, not derived—this cosmology carries the single radiation initial condition, and with no radiation-dominated epoch the light elements as well, from the hot handover of the progenitor collapse, this universe having formed at the event horizon of a black hole in a previous one, equally outside the construction and equally measured.

That the datum is measured rather than derived is no defect: a framework is credited for *requiring* the structure it explains—the geometric rate, and the dissolution that follows—not faulted for measuring the boundary data it does not. *One naturalness argument that has been offered for this datum should be withdrawn rather than carried, because it compares a quantity with itself at two epochs nine orders apart.*

Complete collapse does liberate binding energy of order the rest mass ($GM/Rc^2 = \frac{1}{2}$ at the Schwarzschild radius), and it is tempting to read that as making a handover carrying radiation of order the matter density the natural scale—order unity, rather than the small value η takes. But $\rho_r = \rho_m$ occurs at $T \simeq 0.8\,\text{eV}$, whereas the handover sits four orders *above* the deuterium bottleneck at $0.07\,\text{MeV}$, since that is what the nucleosynthesis computed on it requires [18]: at the bottleneck the ratio is already $\sim 9 \times 10^4$ and at the handover proper $\sim 9 \times 10^8$. A handover carrying radiation merely of order the matter density would be a handover with $\eta \simeq 0.5$, which leaves neither light elements nor acoustic peaks. *So the naturalness question runs the other way*: what the progenitor must deliver is a plasma with of order a billion photons per baryon—the baryogenesis-analogue derivation this paper names as open—and the binding-energy scale offers no head start toward it. *What replaces the argument is a simplification of the bill.* Given η and the measured matter-to-baryon ratio, both of which this cosmology inherits for the composition regardless, the ratio at onset is $[1+\nu](\pi^4/30\zeta_3)\,T_{\text{onset}}/[\eta\,(\omega_m/\omega_b)\,m_N]$, which returns 1.99 at $T_{\text{onset}} = 1.6\,\text{eV}$—the quoted datum, to one per cent, from standard thermodynamics and no feature of this construction. *It is therefore not a second inherited number standing beside η: it is the fitted onset restated*, so what the handover supplies is one composition datum and what the cosmology fits is one parameter (receipt: `the_two_data_are_one.py`[P15R19]). Like

η, the inherited radiation amplitude may remain a measured boundary condition indefinitely without cost to the *dissolution*—which settles what the dissolution depends on, not whether the derivation is worth having. *And the inheritance has a structural reason rather than being a gap left standing* [9, 18]: the infall thermalizes four orders above the deuterium bottleneck, so the progenitor's composition is erased and the abundances are synthesized in the window rather than inherited, while what survives that passage is baryon number, which no dissociation destroys. *So η is inherited and the abundances are predicted*, and the asymmetry is worth stating exactly: baryon number protects the numerator, while what protects the *ratio* is the adiabatic invariance of the specific entropy — the peak perturbing it by 5.5×10^{-10} of a standing $1.15 \times 10^{10}\, k_B$ per baryon, so that η survives the erasure because η is small [18]. *And a derivation of η is not owed, because there is nothing here for one to be about.* It enters the progenitor from the ambient universe by composition-sharing and leaves the branch point unchanged to one part in 2×10^9: *transmitted, not determined* — which is the exact dual of the onset ratio's closure, that one turning on a quantity with no single value to transmit. *So the neighbouring statement strengthens from may to must: η remains a measured boundary condition, at no cost.*

The synthesized composition. The same collapse fixes the light-element composition, and the geometry sharpens how. The infalling matter compresses adiabatically—the plasma is optically thick, so the photon bath compresses with it—and heats far above the deuterium bottleneck ($T_{\mathrm{D}} \simeq 0.07\,\mathrm{MeV}$) for every progenitor: the compression does not stop at horizon crossing but continues to the branch point, and the peak is bounded below by the infall energy at the horizon, of order the rest mass per nucleon, independently of the progenitor's mass (the cosmogenesis paper [18]); at turnaround it re-expands and cools back through the window. Because the effective rate through the window is the standard Friedmann rate, that cooling leg is a standard big-bang nucleosynthesis, run on the collapse's turnaround from a dissociated hot start—the deep re-expansion doing the synthesis below the $T_{\mathrm{onset}} \sim 1.6\,\mathrm{eV}$ onset at which the observable expansion begins. On a first sample this is favourable, and on one element advantageous. The helium-4 fraction $Y_p \approx 0.245$ sits at the observed value; the near-zero metallicity of the oldest systems follows from the handover photodissociating the progenitor's processed composition back to light elements; and because the run is a standard nucleosynthesis, the lithium-7 abundance carries its standard threefold over-prediction—the standing lithium problem shared with flat ΛCDM, neither dissolved nor worsened. Deuterium sits at the observed $D/H \approx 2.5 \times 10^{-5}$: the freeze-out temperature the data demands is the standard bottleneck, and that is exactly the temperature at which the standard rate delivers a freeze-out—target and mechanism coincide un-tuned. The peak calculation that forces this synthesis reading over an inherited one, and the full multi-abundance account, are given in the cosmogenesis paper [18], where the network is now integrated explicitly on the cooling leg and returns deuterium, helium-4 and helium-3 at their observed values with lithium-7 at the shared over-prediction, jointly from the single inherited datum—so one progenitor handover does fit the pattern together; what stands as its open edge is the last-percent precision against the measured abundances, a data-confrontation the produced pattern now exposes rather than a computation still owed.

The load-bearing claim. The acoustic scale stands as a one-parameter accommodation on the radiation datum, not a parameter-free prediction; the standard c_s it borrows presumes the inherited medium to be an ordinary photon–baryon plasma, which the abundance comparison now confirms—helium-4 and deuterium at their observed values, lithium-7 the shared standard problem (the cosmogenesis paper). The load-bearing, falsifiable claim remains the prior one—that radiation carries no term in the expansion rate—of which the dissolved Hubble tension and the one-parameter acoustic calibration are consequences. The sound horizon at a geometrically fixed H_0 is where a purely geometric expansion history and the standard radiation-governed one are told apart in the data.

The expansion history, confronted with the late-time data. The dissolution is not confined to the single microwave-background angle: it holds across the low-redshift distance ladder, and for the same reason.

Because every distance and the ruler alike carry the stacking rate's common factor H_0, which therefore scales out—D_M, $D_H = c/H$ and the sound horizon r_s each scale as $1/H_0$—the baryon-acoustic-oscillation observables D_M/r_s and D_H/r_s are *independent of* H_0, fixed by the offset x_0 alone (the same cancellation that fixes θ_*; §above).

The distinction from ΛCDM is exactly the radiation: there the ruler r_s is pinned in physical length by the radiation-era physical density $\omega_m = \Omega_m h^2$, so the same D/r_s data constrain H_0 and pull it to the low microwave-background value, in tension with the direct one.

Here they do not: the acoustic data fix the offset x_0 and leave H_0 to the local distance ladder, with no second value to reconcile. Confronted with the SDSS DR12 galaxy consensus [21] the geometric rate at $\Omega_m \simeq 0.31$ fits at the directly measured H_0 ($\chi^2 \simeq 1.7$ on six points, at *any* H_0 including 73), where the radiation-governed rate at that same local H_0 misses badly ($\chi^2 \simeq 49$)—that residual is the Hubble tension itself, which the geometric rate structurally lacks. *Stated on the objective rather than on its minimum, the difference is one of curvature RANK and not of value*[L9]: the radiation-pinned $\chi^2(H_0)$ is strictly convex, with a unique argmin that excludes the directly measured value, while the geometric rate's is flat in H_0 — a degenerate Hessian whose argmin is a *line*, and the line contains that value. *So the tension is not a disagreement between two numbers but a property of the surface one of them is a minimum of*, and a rate whose parameters are geometric does not have the surface.

The same confrontation carried to the state-of-the-art DESI DR2 dataset [22]—thirteen distance measurements across seven tracers ($0.3 \lesssim z \lesssim 2.3$), with the full per-tracer D_M/r_s–D_H/r_s correlations—tightens rather than loosens the result: with a single free parameter Ω_m the geometric rate fits at $\chi^2/\text{dof} \simeq 1.0$, at $\Omega_m = 0.3066$ (where the inherited datum sits at $\rho_r/\rho_m \approx 2.0$), and it fits there at *any* H_0 including the local 73—which is the whole of the claim.

The radiation-pinned ruler cannot do that: it ties ΛCDM's fit to one H_0, best at 68.7, and breaks it at 73 ($\chi^2/\text{dof} \simeq 15$)[P15R31].

Two things about Ω_m are worth stating exactly. It is not a CMB-calibrated input here—Planck's own value is 0.3153, at which the fit degrades to $\chi^2/\text{dof} = 1.35$, and 0.3066 is what these data themselves prefer. *And granted the same one free parameter, ΛCDM fits these data marginally better than this cosmology does* ($\chi^2/\text{dof} = 0.92$ against 1.00). *The result is therefore not that the geometric rate fits better; it is that it fits without choosing an H_0, and the radiation-pinned one must choose.* The cosmic chronometers [25], which read $H(z)$ directly, are consistent with the local value. So the resolution is a property of the whole expansion history, not of one angle, and it rides the very rate whose branch point-located scoping keeps the nucleosynthesis window standard [18] (receipt: `hubble_expansion_confrontation_v2.py`[P15R30]; the invariant is the offset x_0, read as Ω_m, and not ω_m—holding the physical density fixed instead imports the ΛCDM reading and manufactures a spurious tension).

2.5 The acoustic modes are sub-horizon at the onset, and the branch point is the opposite

The cosmological beginning is the branch point $r = 0$ at the close of the lift, where the conjugate branch becomes the matter branch [9, 5]. The curvature invariants of the r-chart diverge there because the areal coordinate degenerates, while the throat itself is the substrate's defining constant α and the bead continues through by analytic continuation [35]. The lap's seams lie elsewhere, at the two unit-speed loci $r = -2\alpha/\sqrt{3}$ and $r = +\alpha/\sqrt{3}$. We record the consequence that organizes the perturbation sector.

Proposition 1 (Where the acoustic modes stand at the plasma's onset, on the rate they run on)**.** The answer depends on which rate the question is asked of, and the rate rule (§2.4) fixes which: a process running *in* the content—the perturbations among them—takes the leaf's.

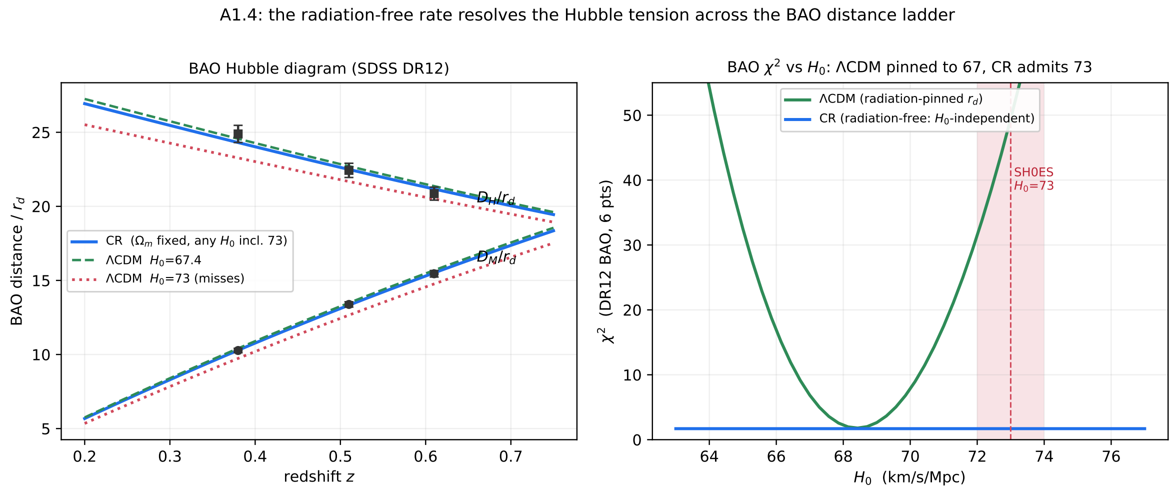

Figure 2: The Hubble tension resolved across the baryon-acoustic distance ladder. *Left:* the SDSS DR12 measurements of D_M/r_s and D_H/r_s (points) against the geometric rate at the directly measured $H_0 = 73$ (solid) and flat-ΛCDM at $H_0 = 67.4$ (dashed); both track the data, while ΛCDM forced to the local $H_0 = 73$ (dotted) misses. *Right:* the BAO χ^2 as a function of H_0. Radiation in the ΛCDM rate pins the physical ruler r_s, so its χ^2 is a steep parabola minimized near 67 and excluding the local value—this is the tension. The geometric rate carries H_0 out of the ratios D_M/r_s, D_H/r_s, so CR's χ^2 is *flat* in H_0: the BAO fixes Ω_m and admits the SH0ES $H_0 = 73$ [24] (shaded) at no cost. The tension is structural to a radiation-governed ruler and absent from a geometrically fixed one. The figure shows the SDSS DR12 consensus; the same result holds, more strongly, against the state-of-the-art DESI DR2 dataset (thirteen measurements, seven tracers), where the geometric rate fits at $\chi^2/\mathrm{dof} \simeq 1$ with the single CMB-calibrated $\Omega_m = 0.307$ at the local H_0 (§2.4).

On the stacking *rate* (6) *the comoving Hubble wavenumber at the onset redshift* $z_\mathrm{onset} \approx 6797$ *is* $k_\mathrm{hor} = H_0 E(z_\mathrm{onset})/[(1 + z_\mathrm{onset})c] \approx 0.011\ \mathrm{Mpc}^{-1}$*, against acoustic peaks at* $k \sim \pi/r_\mathrm{s} \approx 0.022\ \mathrm{Mpc}^{-1}$ *and above—so read there the acoustic modes are inside the horizon at the onset.* On the leaf congruence, which carries a radiation term and is the rate the perturbations evolve on, the census returns the opposite for the relevant band*:* $k_\mathrm{hor} \approx 0.018\ \mathrm{Mpc}^{-1}$*, every multipole below* $\ell = 237.7$ *is still* super-*horizon when the plasma starts, and the band* $155.6 < \ell < 237.7$ *enters the horizon* while radiation dominates*—the leaf background having a matter–radiation equality at* $z_\mathrm{eq} = 3936$*, which the onset at* $z = 6761$ *precedes. The first peak sits inside that band, at* $k/aH(\mathrm{onset}) = 0.858$*, entering at* $z = 5590$*.*

The two epochs this proposition could be read as concerning are distinct, and the distinction is load-bearing[P15R72]*.* z_onset is a redshift on the expanding leg—the redshift at which the expanding-phase plasma begins, and the lower limit of the sound-horizon integral above. *It is not the branch point.* The branch point is the locus $r = 0$, which no finite cosmic-time layer reaches and which therefore carries no finite redshift at all. *The proposition concerns the onset and nothing else*: the acoustic modes are inside the horizon when the plasma they oscillate in comes into being, which is what the transfer calculation requires of them.

And the corresponding statement about the branch point is the opposite one, for a different reason. Approaching $r = 0$ on the contracting leg the comoving Hubble scale aH grows without bound, so the comoving horizon shrinks to zero and every mode *exits* it before the crossing—which is why what crosses is frozen and non-oscillatory (§3). *That statement is about the crossing and stands whatever the census at the onset returns*, the two loci being distinct; reading either at the other's locus inverts it.

Argument. Direct evaluation of $E(z) = \sqrt{\Omega_m(1+z)^3 + \Omega_\Lambda}$ at z_onset and of π/r_s with the banked r_s from the acoustic-scale resolution (§2.3); clean residuals (receipts: `verify_numeric.py`, anchor 7[P15R10]). □

The consequence is that the acoustic band is not one regime but two, and the division is at a computed multipole rather than a chosen one. Above $\ell = 237.7$ the modes are inside the horizon when the cosmological side begins, and for those the branch-point handover is what fixes amplitude and phase, there being no super-horizon interval left in which anything else could. Below it they are not, and the sub-band $155.6 < \ell < 237.7$—which contains the first peak—enters while radiation dominates, so those modes have a driving history on the observable leg of the kind the standard picture gives them. *What this settles is a premise and not a mechanism*: it fixes where each mode stands when the plasma starts, and it does not measure how much of the comb the driving then supplies. That measurement is the transfer of §4.7, which measures the driving directly; the division above is a statement about the census, and the transfer is what carries it to the comb.

3 What crosses, and what does not

The transmission dichotomy above is an argument from the absence of an imprinted scale. A mechanism can now be given for it, and it also settles which content the branch point does *not* carry.

The imaginary-time segment preceding the branch point acts on a perturbation as a Euclidean kernel [34], damping a mode of frequency ω by $e^{-\omega|\Delta\eta|}$ with $|\Delta\eta| \simeq 1.8\times10^4$ Mpc. Taken naively this would annihilate everything: at $\ell = 220$ the factor is 10^{-71}. *But ω is the frequency of an* oscillating *mode, and at the branch point no mode is oscillating.* On the contracting leg the comoving Hubble scale $aH = |\mathrm{d}r/\mathrm{d}\tilde{\tau}| = \sqrt{|1-f|}$ grows without bound as $r \to 0$—it is 0.13 at the comoving turnaround, 1.96 at $|r| = 0.1\,\alpha$, and 19.6 at $10^{-3}\alpha$—so the comoving horizon $1/aH$ shrinks to zero and *every* mode exits it and freezes before the crossing. A frozen mode has no oscillation for the kernel to damp. *So the amplitude and the tilt cross unaltered, and the argument from the absence of a scale is recovered as a consequence of horizon exit rather than assumed.*

What does not cross is the oscillatory content itself, and that is the collapse leg's acoustic phase: a mode that was sub-horizon earlier carries an oscillation, and the kernel annihilates it—an exponent of -152 at the first acoustic peak, integrated across the segment's own sound-speed profile rather than at the single value the estimate above uses[P15R73]. This is required independently by the observed peak positions, which exclude a transmitted leg phase by a factor of 21–41 in the required distance [9], and it is what leaves the comb to be set on the expansion side by the characteristic data of §4. *The two results are one statement*: the crossing transmits what is frozen and destroys what oscillates, so the progenitor supplies the spectrum's amplitude and shape while supplying none of its phase.

The exponent has two factors, and the argument above varies only one of them. It is $e^{-kc_s|\Delta\eta|}$: holding c_s at the plasma's value and varying k reads it as a *scale* criterion, frozen against oscillating, which is the reading just given. Holding k and varying c_s reads the same inequality as a *species* criterion, and that reading supplies something the first does not. A pressureless component has $c_s = 0$ identically—not small, not slowly varying—so its exponent vanishes at every wavenumber; on the segment its mode equation is $\psi'' = 0$, whose constant solution the kernel leaves untouched with no approximation at all. *The matter sector's inheritance is therefore exact rather than adiabatic*: it does not rest on horizon exit and it does not degrade at small scales, where the frozen-mode argument does. The two arguments agree wherever both apply, and only the pressureless one is available everywhere. *Neither reading carries a constraint the other lacks.* On this geometry the exponent at the first acoustic peak is $\simeq 1.6\times10^2\, c_s/c$, so a component with a per-cent sound speed would arrive suppressed by $e^{-1.6}$ and one with ten per cent by e^{-16}, which reads as a sharp condition on what the progenitor may hand over—perturbations inherited from a *cold* species and from no other (receipt: `the_filter_is_a_sound_speed_filter.py`[P15R73]). *The reading is too strong, because the exponent has nothing to act on.* The kernel acts on *os-*

cillatory content—a frozen, zero-frequency mode is a fixed point of it—and on the progenitor's own interior nothing arrives oscillating: $|aH| = |a'/a|$ diverges as $1/x$ at the branch point while c_s saturates at $1/\sqrt{3}$, so $c_s k/|aH| \to c_s kx \to 0$ for every k, and every mode from $\ell \simeq 28$ to $\ell \simeq 2475$ exits the comoving sound horizon strictly before the crunch—the highest with a fifth of a per cent of the collapsing leg still to run [18]. *So the two readings do not divide the work between them: the scale criterion is satisfied by everything, and the species criterion selects nothing.*

One consequence of that freezing bears on the acoustic sector rather than on the crossing, and it is computed rather than left as an inference. If every mode is outside the comoving horizon at the branch point and the acoustic modes are inside it at the onset (Prop. 1), then between those two loci the modes *re-enter*—and in flat ΛCDM a horizon crossing is exactly where the k-independent acoustic driving phase shift is acquired. *The re-entry is real and its boundary is computable*: the mode whose crossing coincides with the onset is $k = 0.0111\,\mathrm{Mpc}^{-1}$, i.e. $\ell \simeq 144$, so every mode at and above the acoustic peaks crossed before the plasma began while $\ell \lesssim 144$ is still outside at the onset and crosses later[P15R55]. *But nothing is imprinted there, and the reason is structural rather than quantitative.* On the geometric rate the crossing occurs under pressureless matter to better than a part in 10^4, and the potential equation for a pressureless component, $\Phi'' + 3\mathcal{H}(1+w)\Phi' + [2\mathcal{H}' + (1+3w)\mathcal{H}^2]\Phi + wk^2\Phi = 0$, *contains no k at all once $w = 0$*—the wavenumber enters only through the pressure term. Integrated on this background from $a = 10^{-7}$ to the onset the potential is constant to twelve digits and *identical across four decades in k*, the integrator taking the same number of steps for every mode because it is handed the same problem. *So the horizon crossing is not an event for the potential here*: before the onset the perturbation problem on the observable leg is scale-free, and a scale-free problem imprints nothing. In flat ΛCDM the same modes cross under *radiation*, where $w = 1/3$ restores the k^2 term and the potential decays on the sound-crossing time by construction, which is why that shift is the same for every mode. *This closes a candidate mechanism rather than supplying one*: the absence of a universal driving shift on this rate is not an omitted crossing but a scale-free interval, and the first peak's position is left open by it.

And that difference is measured rather than argued, model-free, by subtraction against an undriven reference that calibrates at unity: the control's acoustic phase at first turnover is *flat in wavenumber to* 2.1%, where this arm's varies by a factor of 3.9 across the same band[P15R57]. *So the scale-free interval is not an inference from the potential's form but a shape read off the two arms*, and the contrast is with a reference whose own answer is known. The crossing is lossless for every species rather than for cold ones alone. *That is a loss of a claimed prediction and not a gain, and it is recorded as one*; what survives is the pressureless argument's positive content, that the inheritance is exact rather than adiabatic, now holding of every species and not of dust alone.

4 What the substrate determines: coherence from the null boundary

The acoustic peaks are sharp because the modes of a given wavenumber share a common phase at last scattering. Inflation produces this coherence dynamically, by freezing modes while super-horizon; Proposition 1 closes that route here. CR obtains it instead from the character of the branch point.

The branch point is a *null* surface—the cosmological horizon promoted to the initial layer [9]. The initial-value problem on a null surface is characteristic, not Cauchy: the data that determine the future are one free function per mode on the surface together with regularity along the generators, rather than a field and an independent momentum. A single datum per mode is a single phase per mode; there is no second, independently specifiable quantity to randomize the relative phase.

We therefore argue that coherence is not imposed but is what regular characteristic data on a null surface *is*.

This is borne out quantitatively, and the scope of the demonstration is stated exactly.

Evaluating the tightly-coupled mode function at last scattering with a *common* seam phase gives a sharp regular comb, whereas drawing the phase independently per mode—the second, free datum a Cauchy surface would admit—washes it out entirely, leaving flat power (peak-to-trough contrast ~ 1 against the coherent comb's many orders of magnitude; receipt: `verify_coherence_comb.py`[P15R11]). *That establishes the mechanism—one characteristic datum per mode is one phase per mode, and coherence follows—and it establishes nothing about where the peaks fall.* The receipt writes the mode function down as $\cos(kr_{\mathrm{s}})$ with r_{s} and D_C as literals—and the r_{s} it writes is the *standard* 147.0 Mpc rather than any value this construction derives; no mode is propagated in it, as its own scope note says, so the spacing $\Delta\ell \simeq \pi D_C/r_{\mathrm{s}} \approx 296$ is the arithmetic of an assumed expression on an imported ruler rather than an output. *It is not the result of propagating the modes, and is not offered as one*[P15R54].

What the peak spacing lacks is not agreement but a derivation: it is asserted here and computed nowhere in this paper, and the transfer that would compute it is the open one of §4.7.

The null boundary admits only the first column: one characteristic datum per mode is one phase per mode.

The peak *heights* are then carried by a structural argument rather than a bespoke transfer. The driven acoustic amplitude is the resonant Fourier magnitude of the potential's evolution, $|\tilde{\Psi}(\omega{=}1)|$—exactly invariant under time reversal, $|\widetilde{\Psi(x)}| = |\widetilde{\Psi(-x)}|$, a Fourier theorem confirmed numerically on the radiation-era transfer function and on a random control[P15R13].

This cosmology's driving lives on the *contracting* side—the progenitor's radiation-comparable collapse phase, whose potential evolution is the Friedmann time-reverse of an expanding radiation era—so its driving magnitude equals flat ΛCDM's exactly, and the branch point's faithful transmission (§8) carries it across unaltered.

The acoustic amplitude, and with it the peak-height pattern, therefore match flat ΛCDM's—by the time-reversal structure, not by tuning—conditional on the inherited medium being the ordinary photon–baryon plasma, the condition the abundance comparison confirms (§2.4; receipt: `cr_collapse_driving.py`[P15R12], the driving validated as a linear oscillator against the known radiation-era boost).

One premise that argument once carried has to be withdrawn, and withdrawing it leaves the conclusion unsupported rather than merely unproven. It was said that a geometrically fixed rate possesses no expanding radiation era at all, so that the contracting side was the only place driving could live. *That census was taken on the stacking rate, and the three-level rule assigns the perturbations to the leaf* — which has a matter–radiation equality at $z_{\mathrm{eq}} = 3936$ with the onset at $z = 6761$ preceding it. *So the leaf does possess an expanding radiation era*, and the modes carrying the first peak are still super-horizon when the plasma starts and enter while radiation dominates.

And the transfer measures what the structural argument predicts, and does not find it. The height ratios this arm returns are $P_1/P_2 = 1.759$ and $P_1/P_3 = 1.612$ against the sky's 2.217 and 2.277 — a deficit of 20.7% and 29.2%, deepening with peak number. *The heights do not match flat ΛCDM's on this construction's own instrument*, and the structural argument above cannot be read as establishing that they do. *What produces that pattern is not settled here*, and the reason is sharper than an unanswered question. The transfer never integrates the collapse leg: that leg enters through a handover datum of three numbers per mode, and *its two halves are read at different points of it* — the photon amplitude carries the closed-form transfer this paper derives, and the potential is set to its primordial value. So the expanding-leg driving is re-applied from a potential the collapse leg has already spent, onto an amplitude that has not.

And the factor by which this arm is driven harder than the control is a property of that *choice.* Carrying the decay across to the potential does not halve the driving — it doubles it again, to five times the control's, and moves the first peak further from the sky rather than back. Reading both halves at the same point removes the source altogether and the comb above the first peak with it. *Three codings, three answers*, so the factor is not yet a property of the construction.

The mechanism is not thereby wrong: it remains the only account giving the direction, the ordering with peak number and the overshoot together. *What is established is that this instrument cannot presently weigh it*, and what would settle it is not another spectrum but a statement of what the photon perturbation and the potential both are *at one locus.*

Because the acoustic modes are already sub-horizon at the seam (Prop. 1), each mode's driving is complete on the collapse side—and the qualification its own receipt carries is that completeness holds for the modes whose entry precedes the horizon maximum at $r_* = 1.53\, r_{\rm seam}$, entry on the rising branch being earlier the higher the wavenumber, so the acoustic band is on the safe side of that boundary by construction and the low-k end is where it would bite[P15R41]; the observed peaks therefore *reduce* to flat ΛCDM's—the driving equality above together with the shared photon–baryon plasma and the coherent seam phase—and match a Boltzmann reference digit by digit ($P_1/P_2 \approx 2.2$, $P_2/P_1 \approx 0.45$, $P_3/P_1 \approx 0.44$; `camb_reference.py`[P15R14]). What remains is confined to the *damping* tail ($\ell \gtrsim 1000$), and the three-level rule (§2.4) fixes it rather than leaving it to judgement. Recombination is observable cosmology from the branch point onward, so the photon diffusion length r_D—like $r_{\rm s}$—is an L1 quantity: the random walk accumulates against the layer's own geometric expansion, its Thomson microphysics ordinary content physics but its expansion the L1 rate, *not* a radiation-included one.

This is the same branch point-located scoping the cosmogenesis paper derives for the nucleosynthesis window [18], read here in the opposite direction: there the self-gravitating excursion sets the L2 rate radiation is included in, here the diffuse plasma rides the L1 foliation radiation is excluded from.

This is forced: it is the same L1 rate that dissolves the Hubble tension, and one may not take the rate geometric for the peak spacing and radiation-included for the diffusion. The geometric rate is ~13% below the radiation-included one at recombination ($\rho_r/\rho_m \approx 0.3$) and further below it earlier, where the inherited radiation is a larger fraction; *the diffusion length integrates that whole history rather than its endpoint*, and runs ~9% longer than ΛCDM's while $r_{\rm s}$ is matched to the observed acoustic scale (the closed-form derivation of §4.2 gives 10.8% on a sharper ionisation treatment, and the two are related there); the projection-independent ratio is therefore $\theta_D/\theta_* \approx 1.08\,(\theta_D/\theta_*)_{\Lambda\rm CDM}$—a 8.2% larger damping angular scale at the onset redshift used there, the value moving with $z_{\rm onset}$ as §4.3 sets out (receipt: `damping_ratio_clean.py`[P15R15], validated against a Boltzmann reference on the radiation-included rate; $r_{\rm s} = 144.0$ vs CAMB 144.4 — a 0.28% disagreement against the 8.2% signature it feeds, so the reference agrees to thirty times the effect and the margin rather than the agreement is what the word *validated* is carrying[12]; and what a stated tolerance is carrying anywhere in this corpus's computational layer has since been measured rather than assumed—every `abs(...)<tol` comparison in the receipts rewritten twice, once to displace the compared quantity above its tolerance and once to collapse it below, so that 243 of the 245 receipts that pass are shown to have at least one such comparison that actually gates their verdict, the two exceptions being a display filter and a skip that prints its own reason[12L22L22]).

This is the one genuinely CR-specific piece of the height pattern: a real signature *locked to* the Hubble resolution by their shared L1 rate—not an artefact of laying the standard radiation-governed $r_{\rm s}$ on the geometric rate, the calculation belonging to neither framework this paper warns against (§1).

One thing about this signature is settled and one is not, and it is essential to keep them apart.

Settled: the ~9% in r_D is genuinely CR-specific and does not dissolve under the density that would ordinarily rescale it—$r_D \propto \omega_b^{-0.31}$, so a percent-level ω_b (fixed by primordial deuterium and the peak-height ratio) shifts it by well under a percent (receipt: `damping_reabsorption.py`[P15R16]). *And what the signature does to the observed high-ℓ power is now measured, with a verdict that is neither of the two a reader expects.* Scaling the diffusion length by the instrument's own measured ratio multiplies the damping by a Gaussian in ℓ, and a tilt is a power law — so over a restricted high-ℓ range the one is well approximated by the other. *Refitting amplitude and tilt therefore absorbs the signature almost entirely in shape*, leaving 0.26 per bin over the 185-bin ceiling and less the higher one looks. *But the absorption is bought, not free*: it costs a shift of -0.0304 in the inferred tilt against a σ of 0.00323 derived from the same covariance that scores the fit. *So the signature does not vanish under a refit — it moves out of the spectrum's shape and into an inferred parameter. What a refit buys in shape it pays for in parameters*, and that direction is the robust part.

And how local that approximation is can be stated exactly, which settles what a joint fit would actually meet. The signature's own logarithmic slope is $\mathrm{d}\ln(\text{ratio})/\mathrm{d}\ln\ell = -2(r^2-1)(\ell/\ell_D)^2$ — *not a constant, but growing as ℓ^2*: across the likelihood's own $\ell = 30$–2508 it runs from -0.0002 to -1.31, a factor of seven thousand, which is exactly $(\ell_{\max}/\ell_{\min})^2$[P15R3]. *So a single tilt is a one-parameter fit to a function whose slope varies by that factor over the data it is scored on*, and the displacement quoted above is the signature's true slope at $\ell = 381$ and at no other multipole. *The consequence is the useful part*: a joint fit does not encounter a shifted tilt but a residual whose *shape* is a Gaussian in ℓ, and no tilt removes a Gaussian — so what such a fit weighs is the shape residual, which is the quantity already bounded from above. *And a displacement in n_s is not by itself a tension here*, the tilt being inherited boundary data rather than predicted: a different value of an inherited input is a different input. *What could be a tension is a constraint on n_s that does not run through the damping tail* — the low- and mid-ℓ shape, the polarisation spectra, lensing — which is what a joint fit means and is where the question properly sits.

Two bounds travel with that and neither can be left to a reader. The shape residual is an upper bound: freeing only the named degeneracy is the least absorption a fuller refit could achieve, so a wash is a wash *a fortiori*. *The tilt displacement is not a bound*, because more free parameters would share it — the baryon density moves the diffusion length itself. *And the magnitude is not robust to a factor of three*: imposing the ratio on the measured spectrum gives the figures above, while applying it inside the instrument's own source — where it also reaches the Doppler term through a derivative — gives 0.92 per bin. *The larger comes from the more faithful route, so the wash is stated at the weaker bound* and closing that factor is named here as work not done.

Not settled: whether a displacement of that size in the inferred tilt is a tension, which is a statement about a joint fit not performed here. The observable is $\theta_D/\theta_* = r_D/r_\mathrm{s}$, and translating it into a spectrum requires the full acoustic transfer—above all, whether CR's high-ℓ peaks, driven on the geometric rate, track flat ΛCDM's, which is verified only through the third peak ($\ell \lesssim 800$). A leading-order pass that simply *assumes* the high-ℓ peaks equal ΛCDM's and applies the extra damping produces a large high-ℓ deficit (receipt: `full_transfer_verdict.py`[P15R20])—but that assumption may not be imported for free: the same geometric rate that enlarges r_D also governs the high-ℓ driving envelope, so CR's high-ℓ spectrum rests on short-wavelength collapse-phase driving rather than on the boost an expanding radiation era supplies.

One thing about that figure should be stated because two of this corpus's instruments do not agree on it, and the disagreement is worth knowing rather than averaging. The 9% above is the observable θ_D/θ_*, computed on standard thermodynamics with the sound horizon re-anchored to the observed acoustic scale so that only the damping length moves. *The two-arm transfer, measuring the raw diffusion length at the visibility peak, returns* 7.55% *on its own arms — a different quantity at a different epoch, and not a correction to this one. Neither number is offered as a replacement for the other*, and closing the gap between the two routes is a thing this paper does not do.

That driving is computed below (§4.1), and the calculation removes the licence the shortcut lacked: the envelope is derived on the collapse leg rather than imported.

The two structural facts—peaks-match (verified low-ℓ) and diffusion on the geometric rate—therefore constrain, but do not by themselves determine, the high-ℓ shape; the net effect is computed in §4.2; whether it is a tension, a wash, or a distinctive but consistent feature turns on a parameter refit and on the early integrated Sachs–Wolfe term. *That refit is performed here. Fitting both arms to the Planck 2018* **`plik_lite`** *binned TT likelihood over its 215 bins* ($32 \leq \ell \leq 2492$)*, with the same five parameters* ($H_0, \omega_b, \omega_c, A_s, n_s$) *free in each and the published covariance, returns* $\chi^2 = 397.13$ *for this construction against* $\chi^2 = 206.44$ *for flat* Λ*CDM*—1.891 *and* 0.983 *per degree of freedom respectively, so* $\Delta\chi^2 = 190.7$ *at equal fitted-parameter count. The control reproduces the sky essentially perfectly, which is what makes the comparison readable at all; and the verdict it returns is that the spectrum derived here is disfavoured against the standard model on this data. We state it as it stands. What it measures is the five-parameter fit of the spectrum construction, not the geometry that motivates it, and the two are joined by the transfer work of this section rather than by identity.* What is honestly claimed here is the *effect*, not a verdict on it: a real, computed, non-reabsorbable ∼9% CR-specific diffusion-scale signature, its observable consequence now derived rather than entangled (§4.2), and the verdict on it left to a likelihood confrontation this paper does not run. The structural point that stands is the *mechanism*: where inflation freezes the phase dynamically and drives the amplitudes on an expanding radiation era, CR fixes the phase geometrically on the single null layer and drives the amplitudes on the time-mirrored collapse.

4.1 The collapse-phase driving envelope

The driving named above can be carried out in closed form, and doing so removes the entanglement the previous subsection had to leave standing. On the radiation-dominated collapse leg the potential obeys $\Psi'' + (4/\eta)\Psi' + (k^2/3)\Psi = 0$, whose regular solution is elementary, $\Psi = 3\Psi_i(\sin x - x\cos x)/x^3$ with $x = k\eta/\sqrt{3}$, and which is *even* in x[P15R40]—so the contracting leg carries the same closed form pointwise, a sharper statement than the Fourier-magnitude equality of §4 and consistent with it. Writing $\hat\Theta = \Theta_0 + \Psi$ removes the source exactly, $\hat\Theta'' + (k^2/3)\hat\Theta = 0$: the effective temperature oscillates freely, and the k-dependence rides entirely in the amplitude at horizon entry and in the decay of Ψ.

Horizon entry is fixed by the construction rather than fitted. The comoving Hubble radius is built from the slicing paper's own turnaround function, $(rH)^2 = (1-f) + A/r^2$ [5], and has a single turning point on the whole excursion, at $r_* = 1.53\, r_{\rm seam}$ on the corpus's inherited datum; the *seam* sits just inside that turning point, on the rising branch, so the acoustic modes are already within the comoving horizon there—which is the geometric content of Prop. 1 rather than a numerical accident of $z_{\rm onset}$[P15R41]. *The locus matters and the two available ones give opposite answers*: the branch point lies at the far end of the same rising branch, where $2M/r \to \infty$ carries aH up without bound and the comoving horizon to zero, so there *every* mode is outside it (§3). It is the seam, not the crossing, that this construction reads—the inversion derived from the metric function rather than asserted[P15R72]. On the leg the radiation term dominates because it is constant while the others vanish, so $\eta = r/\sqrt{A}$ to about two per cent at the entry radius of the lowest mode in question and better the deeper the mode enters—sub-percent from $k \gtrsim 30\, k_s$[P15R42], and entry then occurs at $x \to 1/\sqrt{3}$ *in the deep sub-horizon limit*—the radiation era's own scale invariance, recovered here from the substrate geometry. *The envelope is therefore flat to the accuracy of that limit*: a mode at $k \simeq 10\, k_s$ enters within 2% of $1/\sqrt{3}$ and one at $300\, k_s$ within 0.1%, all of them reaching the *seam*—where the collapse leg ends—with the same driving amplitude $\Psi(1/\sqrt{3})/2$, and the residual potential is below a percent *on average* while oscillating up to some seven per cent of it where $\cos x_{\rm seam}$ is near an extremum[P15R43]. *Both are qualifications rather than identities: the limit is a limit and* *the average an average.* Its turnover sits at equality, and the inherited datum places equality at $1 + z_{\rm eq} = (1 + z_{\rm onset})/2 = 3399$, essentially flat ΛCDM's—so the envelope turns over at the same wavenumber, for a structural reason and not by assumption[P15R46].

Two corrections that might have been expected do not enter. The baryon loading is proportional to the scale factor and the driving happens where the scale factor is smallest, so $R \lesssim 0.1$ at the onset and orders below that at entry; the odd/even asymmetry is imprinted afterwards, on the expansion side at $R \approx 0.6$, which is ordinary content physics on the observable leg. *The sky's own value, located by parabolic fit on the Planck binned spectrum, is* $P_1/P_2 = 2.2564 \pm 0.0772$*, and flat ΛCDM's is* 2.200*;* what this construction returns for the same quantity waits on the transfer of §4.7, since a peak height is exactly what an unconverged wavenumber integral misreports[P15R44]. The structural point stands without it*: the loading is the same in both because it is imprinted on the expansion side, and the argument is at the level of contents rather than of the driving—where the loading ratio alone would give* 3.5*.* And the free-streaming neutrinos the cooling-leg nucleosynthesis requires do carry anisotropic stress at these temperatures—the branch point is far below their decoupling—but their deep sub-horizon effect is a constant phase shift and a constant suppression, and a k-independent correction leaves a flat envelope flat[P15R45]. What it does not leave is the closed form for Ψ itself, the equation becoming integro-differential; the closure is a property of the skeleton, and the flatness is what survives.

4.2 What the envelope buys, and what remains

With the envelope derived rather than assumed, the diffusion signature can be stated without the entanglement. The diffusion length reduces to a single integral over the scale factor in which every microphysical constant sits outside, $1/k_D^2 \propto \int {\rm d}a\, g(R)/(Hx_e)$, so in the ratio the Thomson physics and the ionisation history cancel identically and the whole difference is carried by $H(a)$—which is the division of labour this section has argued for throughout. Both integrals close in elementary form, and on the inherited datum the geometric rate gives a diffusion length 10.8% longer[P15R47]. *That is the closed-form value and it stands beside the* 9% *quoted above rather than replacing it*: the earlier figure runs the ionisation history through a Boltzmann-validated recombination, this one takes x_e as a sharp cut at $a_{\rm rec}$ and carries the inherited datum unchanged to recombination. *The two are independent routes to one quantity and agree to about a point and a half*, which is the relationship an elementary derivation should bear to a code-validated one. The sound horizon is the same kind of integral, and it must be taken *from the branch point*: there is no observable expansion below it. Doing so returns $r_s = 146.4$ Mpc against 145.4 on the radiation-included rate—within 0.7% of each other at the onset redshift the inherited datum fixes, the exact crossing sitting a little lower at $z \simeq 6.7 \times 10^3$[P15R48]—the acoustic-scale calibration, met from the other end and to that accuracy rather than exactly. *Both are the elementary integral; carried through a full recombination history and validated against a Boltzmann reference the same two come out at* 144.0 *and* 144.4*, a per cent lower and in the same relation*[P15R15]. The observable, in which the common distance cancels, is then θ_D/θ_* larger by 8.2% at this onset redshift, and $\ell_* = \pi D_M/r_s = 302.2$ against the measured 301.76[P15R37].

The high-ℓ consequence follows with no free parameter: $C_\ell^{\rm CR}/C_\ell^{\Lambda{\rm CDM}} = \exp[-(\ell/\ell_D)^2(r^2 - 1)]$ with $r = \theta_D/\theta_* = 1.082$—the same ratio the preceding paragraph derives, and nothing else—so the ratio is 0.84 at ℓ_D and 0.68 at $1.5\,\ell_D$[12]. *Whether that is a tension is a separate question this paper does not settle*: a confrontation refits the cosmological parameters, which is a likelihood analysis and not a closed-form calculation, and asserting exclusion from these numbers would repeat, at one remove, the error of holding everything else fixed while varying one thing. What has changed is the standing of the signature. The signature is a requirement of the construction, following from the inherited datum and the level assignment and nothing else.

The early integrated Sachs–Wolfe contribution is present here, and the step that once denied it is worth setting out because the denial was an inference and not a measurement. The rate at recombination is matter-dominated to nine orders, the substrate term being utterly negligible there[P15R39]: *that is true, and it is a statement about the rate.* The geometric rate carries no radiation term, radiation being inherited content read off the clock rather than something that sources the rate.

But the effect is driven by the radiation ***content*** *through the perturbation source, not by the rate.* The content enters the source under either rate assignment, and *at recombination this cosmology's content is* 21.7% *radiation*, $\rho_r/\rho_m = 0.2765$ at $z = 1088$ — which no statement about the rate's composition bears on. *So the inference from a radiationless rate to an absent term does not hold*, and the term is present.

Measured, as the integrated $|e^{-\tau}(\Phi' + \Psi')|$ *after recombination in units of the Sachs–Wolfe amplitude there*: 0.348 on the leaf congruence the rate rule assigns the perturbations to, and 0.229 on the stacking rate. *Non-zero on both. The leaf assignment makes the term half again larger; it does not create it.*

One scope qualification is owed here, and it narrows the claim without touching the conclusion. The constancy argument runs on $\Phi'' + 3\mathcal{H}\Phi' = 0$, which is the *super-horizon* equation: it drops the $k^2\Phi$ term. For the acoustic modes—inside the horizon at the onset and remaining so—that term does not vanish, and the potential does decay on the observable leg, by a factor of order two across the first few peaks[P15R38]. The decay is not a radiation effect: zeroing the radiation fractions in the constraint makes it *larger*, and the rate responsible is $k^2/(3\mathcal{H})$, which grows with k and refers to no content at all. So the statement that survives is that *the substrate rate supplies no early integrated Sachs–Wolfe term*—which is what the leftward reading delivers and what the comparison with flat ΛCDM turns on—while the sub-horizon potential decay is an ordinary consequence of the perturbation's own scale, present in any cosmology.

The missing contribution cannot offset the diffusion signature, and the reason is structural rather than numerical. It sits near the first peaks and dies away well before the damping tail begins, so the two live at opposite ends of the spectrum; and the first peak is where the amplitude is anchored, by an A_s this construction inherits rather than predicts. A few per cent there is absorbed by that inherited normalisation, exactly as it would be in a framework carrying η from outside. The diffusion signature is not so absorbed: it is a change of *shape* at high multipole, and rescaling the amplitude to restore the first peak would worsen the tail rather than repair it. *What stands between the derivation and a verdict is therefore the likelihood confrontation alone*—a parameter refit, not a further calculation of this kind, and one that waits on the transfer of §4.7.

4.3 The diffusion scale, and the error budget

The acoustic scale is met at the directly measured H_0; the diffusion scale is not free to follow it. Holding ℓ_* to its measured value fixes the onset redshift, and θ_D/θ_* then follows with nothing left to adjust: it varies from +43% to −3% across the onset redshifts one might consider, so a single datum cannot absorb both observables. *One inherited number, two observables, and the first is spent on the first.* Run at the directly measured $H_0 = 73$, the matter density this construction's own baryon-acoustic fit returns, its own light-element baryon density, and the measured photon temperature—with the acoustic angle the single microwave-background input—the seam falls at $z \simeq 6.8 \times 10^3$ and

$$\theta_D/\theta_* \;=\; +13.96\% \;\pm\; 0.89\%,$$

an error budget dominated by the measurement of H_0 itself[P15R68].

That figure and the 8.2% *of §4 are the same observable computed at two onset redshifts, and the difference between them is the honest measure of what this signature is currently worth.* The two differ by 0.53% in z_{onset} and by 5.8 points in θ_D/θ_*, which is the sensitivity the range above already reports—so the quantity is determined only once z_{onset} is, and z_{onset} is the one number this cosmology fits. *The signature is therefore a computed, non-reabsorbable effect of definite sign and of a magnitude the acoustic-angle fit has still to pin*: it does not float with H_0, both r_D and r_s carrying $1/H_0$ so that the ratio is H_0-independent, and it does not dissolve under ω_b; what it awaits is the same refit the high-ℓ verdict awaits. *We quote the two values rather than choosing between them, and no claim below rests on which is right.*

Two contributions that might have been expected do not enter: the last-scattering surface's thickness scales with the rate in both its width and its conversion to comoving distance, so it cancels from the ratio; and the recombination redshift, integrated on this rate through the Peebles equation [37] rather than inherited, moves by only -0.11%[P15R52]. The same integration returns $z_* = 1091$ on the radiation-included rate, against the 1090 of the standard treatment, which is the check that the ionisation history is being handled correctly.

4.4 The integrated Sachs–Wolfe contribution across the first-peak region

The first acoustic peak is a separate matter and it does not move. Its offset from ℓ_*—220 against 301.7—is largely the phase shift the potential's decay imparts while the modes are driven, and that decay has the same closed form on the collapse leg as on an expanding radiation era (§4.1), so it transfers. What does not transfer is the early integrated Sachs–Wolfe contribution, and that turns out to be a nearly *flat* multiplicative factor across the first-peak region—some ten per cent in amplitude, varying by two parts in a hundred between $\ell = 150$ and $\ell = 300$—so it displaces the maximum by one or two multipoles rather than by tens[P15R50]. *The first peak therefore sits where it is measured, and for a reason internal to the construction rather than by accommodation.* That refit can be bounded here, and bounding it is worth doing because the reabsorption question is the whole of what a likelihood would decide about this signature. Pinning ℓ_* to the measured 301 and minimising the residual in θ_D/θ_* over the baryon density and the matter density—the former held to the one per cent primordial deuterium allows, the latter to the five per cent the distance and growth data allow—leaves a residual of several per cent [P15R51]. The baryon density cannot absorb it, having one per cent of freedom against an effect of order ten per cent at either onset (§4.3); the matter density can, but only by moving some thirty-seven per cent, which is not a refit but a different cosmology. *So the shift has a floor, and the floor is the prediction.* We state this as a bound and not as a likelihood: a full comparison fits the whole spectrum with every parameter and its covariances, where this fixes one observable and minimises one derived ratio. It settles that the signature does not dissolve under reabsorption; it does not settle the verdict.

4.5 What the instrument's residual is made of

The two-arm comparison's floor is set by components of the instrument rather than by either cosmology. Two candidates for the accuracy it lacks are measured here.

Of the two, one cannot pay at all[P15R66L23]. Above $\ell \simeq 40$ the whole effect of reionisation on the temperature spectrum is the constant screening $e^{-2\tau}$—the second visibility bump contributes only below $\ell \simeq 30$, outside this comparison's range—and the comparison fits one amplitude in closed form. *An amplitude fitted as $A = (m^\mathsf{T} F d)/(m^\mathsf{T} F m)$ is homogeneous of degree -1 in the model, so rescaling the model returns A/s and leaves the residual unchanged*: the degeneracy is exact rather than approximate, and it is a property of the statistic rather than of the size of τ. Checked at $\tau = 0.054$, 0.10 and 0.30, the change in χ^2 is zero to machine precision at all three. *Lensing is a different matter.* A smoothing in multipole, scanned in width, takes the control from 1320 to 921; and a width that *grows* with ℓ beats a constant one by a factor of 1.8 in the improvement, each compared at its own optimum, so the preference is for a shape and not merely for a size—*which is lensing's own signature, since a deflection of fixed angle subtends* *a larger fraction of an acoustic wavelength at high ℓ. We state what that is and is not.* The width is fitted, so the improvement bounds what a derived calculation has to play for rather than measuring a lensing amplitude; and even at its own optimum some 70% of the residual survives it. *So the lensed spectrum is the next thing this instrument owes, and it is not the last one.*

That calculation is done, and it comes in under the bound the fit set. Applying ΛCDM's own lensed-to-unlensed ratio to the arm—a derived operation with no free width—takes the control from 1320 to 989, an improvement of 331, concentrated in the damping tail where a fixed-angle deflection fills the troughs. *That is below the* 400 *the fitted width bounded, as a zero-parameter derivation must be*, and the acoustic peaks do not move under it. The corpus's own first-order kernel overshoots the bound to 508 by breaking down in that same tail—returning a spurious +13% at $\ell = 1900$ where the full operator gives +6.5%—which is why the derived number is the full operator's. *Most of the fitted headroom is recovered by a genuine lensing, and about* 989 *of the* 1320 *survives it*: the verdict of the last paragraph stands from the derived side, lensing real and not the last build[P15R67].

And what the residual is MADE of was decomposed alongside it, which is what let the size of that gain be anticipated rather than discovered[P15R69]. Projecting named templates through the same inverse covariance the comparison uses, the peak *positions* account for a tenth of a per cent of the residual—*which is why the acoustic peaks do not move under the lensing above, and the two findings corroborate each other*—while the peak-trough *contrast* at fixed position accounts for two-fifths of it, this transfer's contrast running some thirteen per cent too high. *Reducing contrast without moving peaks is what lensing does.* A smooth multiplicative envelope accounts for a further sixth, and *about half the residual is in neither*—so a complete lensing calculation was expected to leave a comparable amount behind, and it did.

4.6 The shear coefficient, derived

The coefficient is derived rather than fitted, and the derivation settles it against the fit[P15R64]. The coefficient is measured by running the same oscillator twice on the same background: once as the perfect tight-coupled fluid, which is undamped by construction, and once as a photon hierarchy carried to $\ell = 24$ with Thomson scattering, the polarisation multipoles evolved alongside and the baryons given their own velocity. *Their ratio is the damping and nothing else*—the slowly varying prefactor, the drift of the sound speed and the baryon-loading dependence of the oscillation are common to the two runs and divide out identically—and reading it locally, between consecutive extrema, lets the residual be extrapolated in $(k/\tau')^2$ rather than smeared over an interval. With the polarisation multipoles suppressed the quadrupole's scattering term reduces to $-\frac{9}{10}\tau' F_2$, which is the unpolarised closure, and the coefficient comes back as 0.8852 against 8/9; with them carried it is 1.0618 against 16/15. *The polarisation correction itself, which is the quantity in dispute, is a factor* 1.1996 *against* 6/5*: three parts in ten thousand.* Both absolute values sit about half a per cent low by an amount proportional to the coefficient, so the residual is a common normalisation and cancels in the ratio.

4.7 The acoustic comparison

Two features of this cosmology's acoustic scale are worth separating, because only one of them is a prediction. The angular scale $\ell_* = \pi D_M / r_s$ is *independent of* H_0 here: both lengths scale as $1/H_0$ on a matter-and-substrate rate, so the ratio does not know about it. In flat ΛCDM there is no free early datum—the sound horizon is fixed by the matter and baryon densities—so the measured angle *does* determine H_0, and that is the origin of the lower value inferred from the microwave background. Here the branch point's radiation amplitude takes that constraint instead, and H_0 is left to be the directly measured one[P15R49]. *So the acoustic scale is an accommodation, and it is spent.*

The seam datum carries two freedoms, and how far the first peak moves with them is measured. The datum §4 states is one amplitude per mode and a *common* phase; it fixes that the phase is common without fixing which phase it is. A second freedom sits beside it: what the amplitude is "flat in wavenumber" *at*, the construction reading its transfer shape at each mode's own horizon crossing where an alternative reads it at each mode's phase at the seam. *Read at converged wavenumber on the leaf congruence, across the seventeen readings admitted by a four-peak criterion fixed before the numbers, the first peak spans* 148 *to* 228 *— a factor of* 1.541*, and across the fifteen numeric-phase readings alone* 1.118*. So the position is not a free statement about the datum*: the span is narrow enough that the reading is a statement of the construction, and the sky's 220.6 lies inside it.

And the same is true of the other three acoustic statistics, which is the weaker fact and must be said as the weaker one. The spacing spans 276.0 to 330.4 against the sky's 294.6, the phase intercept -0.4044 to -0.2161 against -0.2253, and the alternation ratio 0.475 to 1.088 against 0.856: the sky is inside the span on each statistic *separately. A span containing the sky on each statistic one at a time is much weaker than a reading that reproduces the sky, and there is no such reading.*

What the readings do carry is a correlation, and it is the sharpest thing this scan returns. Position and alternation move against each other across the datum: Spearman $\rho = +0.782$ at $p = 2.1 \times 10^{-4}$ between the first peak and the gap ratio, so as the datum carries the peak up toward the sky's value the second gap turns from contracting to expanding. *Of the six readings landing the first peak within one grid step of the sky's, not one contracts; of the seven that do contract, every one sits at $\ell_1 \leq 212$. So the seam datum can buy the position or the alternation and not both*, and no mechanism for that trade is in hand.

The instrument that would measure the rest is built, and its guard and its control are what make it an arbiter. Both arms run on one set of equations, so no comparison between them is a difference of machinery[P15R56]. *The guard first, because it is what licenses the rest.* With every coupling to the potential removed at every site—the $4\Phi'$ in the photon, neutrino and cold-matter continuity equations and the $k^2\Psi$ in the photon–baryon and neutrino Euler equations—the source comb lands on the integers on *both* arms. *So the sound horizon, the measure, the wavenumber grid and the phase extraction are validated as an ensemble, and every departure from $n\pi/r_s$ in a driven run is the driving and nothing else.*

The control is the arm whose answer is known independently, and it reproduces it[P15R65][P15R100]. The photons are carried as a Boltzmann hierarchy with the polarisation multipoles alongside, the baryons given their own velocity and density contrast, and the source carrying $g\Pi/4$ and $(3/4k^2)\,\mathrm{d}^2(g\Pi)/\mathrm{d}\eta^2$. Run on the flat-ΛCDM arm it returns peaks at 220, 540 and 812 against the sky's 220.6, 538.1 and 809.8, and a first-to-second height ratio of 2.1969 against a standard code's 2.200—agreement to 0.14%, and within the sky's own uncertainty.

Two conditions on how such a transfer is run are what that agreement rests on, and the tighter of them is numerical. The projection must carry the polarisation source, which a damping envelope cannot supply at any coefficient; and the wavenumber integral must be carried past the highest multipole *reported*, since $\int P(k)\,\Delta_\ell(k)^2\,\mathrm{d}k$ is not converged there. *Each is worth a factor on its own and neither alone reaches the answer*: the height ratio runs from 2.721 at an ℓ-equivalent cutoff of 900 to 2.393 at 2400, so a cutoff set at the reported multipole is a systematic and not a rounding.

The perturbation sector runs on the leaf congruence, which is what the framework assigns it. A process running *in* the content—the sound horizon, the diffusion length, recombination, the perturbations—takes the leaf's rate (§2.4), while the comoving separations and the projection keep the stacking rate; the change is an exact chain rule between two monotone conformal times, so every spline and grid is untouched, and on the flat-ΛCDM arm the two rates are identical and the assignment is provably a no-op there—which is its own self-check.

The comparison is made on the polarisation path, in the configuration the control is calibrated *in.* There the control returns a first-to-second height ratio of 2.195 at peaks 220, 536 and 814, against a standard code's 2.200: *so the instrument is calibrated where this cosmology's number is taken*[P15R56][P15R61]. *Both arms are converged in the wavenumber integral.* The control's own movement between cutoffs is 0.000% and 0.046% on the two height ratios, and this cosmology's arm does not move at all—0.000% and 0.000%—so the arm is converged at the lower cutoff and the figures below are not a truncation artefact. *The same comparison on the fluid path reads* 0.042% *and* 0.036% *against* 0.000% *and* 0.045%: both paths converge, and the two sets of figures are not interchangeable. *A rung below that was refused outright by the instrument's own truncation guard, on both arms, which is data and not an error.*

On that path this cosmology's arm returns the following, and the comparison does not come out even. The peaks fall at 206, 528, 832 and 1196, with $\ell_1/\ell_A = 0.6830$ against the sky's 0.7312 —*a deficit of* 6.6% *in position*—and height ratios $P_1/P_2 = 1.759$ and $P_1/P_3 = 1.612$ against the sky's 2.217 and 2.277. *Two wavenumber cutoffs agree to every digit. And the positions are converged in the reported multipole grid, which is not free*: they are read on a grid of step 2, and coarsening it to the instrument's default of 8 moves this arm's first peak by two multipoles while leaving the control's unmoved, so the grid was quantising one arm and not the other. Refining to step 1 moves nothing at all — 206, 528, 832, 1196 to every digit.

And the deficit is neither of the two instrument faults a reader would reasonably suspect, because both are removed in that configuration: the wavenumber truncation is carried past the reported multipole, and the projection carries the polarisation source rather than a damping envelope[P15R63]. *And the truncation's removal is measured on the arm whose answer is known*: it was 78% of the control's remaining χ^2, and taking it out brings the control to 1.18 per degree of freedom over the full range against a reference 1.01, *while this arm does not move across four instrument states*[P15R82]. *Nor is the height pattern an instrument artefact*: putting the diffusion damping back — *derived on each arm's own opacity and rate, neither imported nor fitted* — brings the heights from 13–34% to 2–3% and drops the likelihood's floor by a factor of five *without the verdict turning over*[P15R62]. *The polarisation source moreover pulls both arms down by comparable amounts*—the control by 8.2% and 20.8% on the two ratios, this arm by 10.9% and 26.9%—*landing the control on the sky because the control was above it and carrying this arm further below because it was already there. Nothing about the operation differs between the arms*, which is what makes the residual attributable to the source rather than to the machinery.

Two likelihood configurations are quoted in this section and they are not interchangeable, so which is which is stated rather than left to be inferred. The full-range lensed one, on 185 bins, is the better-converged: it is where the control reaches 1.18 per degree of freedom against a reference 1.01, and it is the configuration in which an instrument fault can be told from a physical one. The 133-bin unlensed one is where the shape rejection is quoted, and its control sits at 2.10 per bin because the ceiling cuts the damping tail. *The second is not a worse measurement of the first's quantity*: it is a different configuration, chosen for the comparison it makes, and the two sit beside each other rather than one superseding the other.

The driving's size on the observable leg is measured rather than inferred, and its wavenumber dependence is known in closed form—the k-dependence living in the potential's gradient rather than in its decay, with the turnover at a fixed multiple of the horizon scale[P15R58][P15R59]. Removing it moves this arm's first peak from 206 to 340, and ℓ_1/ℓ_A from 0.6830 to 1.1273: *the modes carrying the first peak are driven, and by* 134 *multipoles' worth*[P15R70]. *Run on the control the same subtraction moves* 220 *to* 276, *a shift of* 0.1858 *in* ℓ_1/ℓ_A *against this arm's* 0.4443—so the arm is not driven less than the control but 2.4 *times as much*, and undriven its first peak already sits 23% higher, at 1.1273 against 0.9158. *The arm therefore overshoots rather than falls short*: the driving carries it from above the control's undriven position to below the control's driven one, past the sky. (Both subtractions are taken on the polarisation path at the lower cutoff; the fluid path gives the same ratio, 2.43 against 2.39.) *And the likelihood is run, both arms scored on the same bins by the same code, with the amplitude fitted so that* *what is compared is shape. The result is a rejection of this arm's spectrum and is stated as one.* Over 133 bins of Planck TT the control returns $\chi^2 = 279.4$, or 2.10 per bin; this arm returns $\chi^2 = 15752.0$, or 118.4 per bin[P15R60]. *The separation between the two models, measured as a distance between them rather than as a difference of two numbers each taken against the sky, is* 122 *per bin — eleven standard deviations per bin*[P15R85].

The configuration limits the absolute values and does not account for the gap. The control sits at 2.10 per bin rather than unity because the multipole ceiling cuts the damping tail on an unlensed spectrum. *What is not configuration-limited is the ratio*: the separation between the arms is 58 times the control's own distance from the data on the same bins. *And the verdict does not turn on which measure is used* — F_2 and the separation statistic agree to within 5%, at 15473 against 16261. *Nor is it a truncation artefact*: cutting at four-fifths of the ceiling the control reads 1.69 per bin over 104 bins and this arm 82.05, so the disagreement is large at both cutoffs[P15R60]. *So the shortfall is not the configuration*: it is the 6.6% position deficit and the height ratios of §4.7, carried across every bin.

What that leaves is a measured deficit with no mechanism. The account that would have covered it—that the acoustic modes re-enter above the plasma's onset so that none is driven—is taken on the stacking rate, and the rate rule assigns the perturbations to the leaf: on the leaf the band $155.6 < \ell < 237.7$, which contains this arm's first peak, enters the horizon while radiation dominates, the leaf background carrying a matter–radiation equality at $z_{\rm eq} = 3936$ that the onset at $z = 6761$ precedes[P15R17].

Two things this section does not claim, and they are separated because a reader would otherwise supply them. The alternation figures above are read on a multipole grid whose step is the same size as the sky's own gap contraction is large, so *the failure to contract at the sky's position is resolved while the small contractions at lower ℓ are not*[P15R71]; a finer grid is what would settle those. And the driving's size is a measurement of the effect, not an account of the deficit: *what remains open is a mechanism, and §10 carries it as such.*

5 What the substrate determines: the amplitude floor and the classical character

One might ask whether the observed fluctuation amplitude is the substrate's own de Sitter vacuum—the natural CR analogue of the inflationary spectrum-is-the-stretched-vacuum story. It is not, by a decisive margin.

Proposition 2 (The substrate vacuum is negligible against the observed amplitude)**.** *The substrate curvature scale is the cosmological-constant scale: in Planck units $\Lambda\ell_P^2 \approx 3 \times 10^{-122}$, and the de Sitter vacuum metric-fluctuation power is of the same order, $(H_\Lambda/M_{\rm Pl})^2 \sim 10^{-122}$. Against the observed $A_s \approx 2 \times 10^{-9}$ this is smaller by $\sim 10^{113}$.*

Argument. $\Lambda = 3(H_0/c)^2\Omega_\Lambda$ gives $\Lambda\ell_P^2$ directly; $H_\Lambda = c\sqrt{\Lambda/3}$ and $(\hbar H_\Lambda/E_P)^2$ give the vacuum power (receipts: `verify_numeric.py`, anchor 5[P15R10]). The prefactor ($\sim 10^{-122}$ versus $\sim 10^{-123}$) is a 2π and reduced-versus-full Planck-mass convention; the conclusion is robust to it. □

One scope qualification is owed immediately, and closing it is what makes the classical reading a result rather than an inference. Proposition 2 rules out the *substrate's* vacuum. But the reading it supports locates the fluctuations in the *progenitor*, and the progenitor's own vacuum is a different quantity: it is normalised at the collapse leg's curvature scale, not at H_Λ, and it is amplified on its way here by the branch point's mode mixing. Neither effect is small, and neither is addressed above. Both can be computed, because the collapse-side background is a single function: with $A = 2M$ and $\rho = 2\sqrt{B}/A$ the exact closed dust-plus-radiation interior gives $a = M(\rho|\sigma| + \sigma^2/2)$ near the crunch, whose Mukhanov–Sasaki potential $z''/z = 2/(|\sigma|(|\sigma| + 2\rho))$ is *independent of the mass*—so M enters only through the final division $\zeta = v/a$. The passage then has exactly three stages, and each contributes one factor of $1/\rho$. A mode leaves the sound horizon on the $\beta = 2$ leg and freezes as $v \to D_k/|\sigma|$ with the scale-invariant $D_k = \sqrt{\hbar/2}\,k^{-3/2}$; the connection through equality is elementary, since $v = a \int \mathrm{d}\sigma/a^2$ solves the $k = 0$ problem in closed form and carries $D_k/|\sigma|$ to the constant $(3/2\rho)D_k$ at the crunch; the crunch monodromy then leaks that constant into the survivor with coefficient $4\pi/\rho$—twice the tensor value, because the true hydrodynamical $z_S = a\big(a + \frac{4B}{3A}\big)/a'$ has $z_S''/z_S \to 2/(\rho x)$ where $a''/a \to 1/(\rho x)$—the companion paper's numerically obtained $-2\pi i/\rho$ [18] being the *tensor* value of the same object, recovered here in closed form as the continuation of the $(\sigma/\rho)\ln\sigma$ term the $(0,1)$ resonance forces; and the survivor's curvature is $\zeta = C/(M\rho)$, the last $1/\rho$ being the crunch's own slope $a'(\eta_c) = -M\rho$. The result is a transfer law with no free constant,

$$\mathcal{P}_\zeta \;=\; \frac{18\,k^3 D_k^2}{M^2\rho^6}, \tag{8}$$

which is *exactly* scale-invariant on vacuum data—the k^3 cancels the k^{-3} identically—and which therefore delivers, for the vacuum, $A_s = 9(\ell_P/M)^2\rho^{-6}$ (receipt: `P15_the_progenitor_vacuum_is_negligible_t` the connection coefficient confirmed against integration from vacuum data to 0.1% over a decade in ρ). *One check is owed here and is not optional, because the hydrodynamical variable differs from a in three places and not one*: $z_S \propto a^{3/2}$ in the matter era, so the exponents there are $(-2, 3)$ against a's $(-1, 2)$; the crunch residue doubles; and the final division is by z_S rather than by a. *Propagating the same physical initial condition under each potential returns a ratio of exactly* 2 *in amplitude at every composition tested*—the matter-era exponents and the change of divisor cancel, and the crunch residue alone survives. So the $z \propto a$ chain is corrected by one factor rather than rebuilt, and Eq. (8) is the true-variable law.

Proposition 3 (The progenitor vacuum is negligible too)**.** *With the mass capped at the recollapse threshold $M \le \alpha/3\sqrt{3}$ and the radiation fraction at the largest value the observed spectrum permits, Eq.* (8) *on vacuum data returns $A_s \sim 1 \times 10^{-112}$, short of the observed* 2×10^{-9} *by* $\sim 10^{103}$.

Argument. $(\ell_P/M)^2 \ge 27(\ell_P/\alpha)^2 \approx 2.6 \times 10^{-121}$ at the cap, and the companion paper determines $\rho \simeq 5.4 \times 10^{-2}$ [18]; $9 \times 2.6 \times 10^{-121} \times \rho^{-6}$ then gives the figure. Running it backwards, the vacuum would reach the observed amplitude only at $\rho \sim 3 \times 10^{-19}$, thirteen orders below what nucleosynthesis on the same leg permits. □

So eighteen orders separate the substrate's vacuum from the progenitor's amplified one—the mixing buying $10^{8.6}$ *over the progenitor's own bare vacuum, which itself sits* 10^{10} *above the substrate's—and it is still short by a hundred and three*, and the classical character of the primordial statistics is now established for the source that actually supplies them rather than only for the one that does not. Two consequences of *character*, not of number, follow.

First, the observed amplitude is inherited classical content—boundary data from the progenitor, not a quantum fluctuation generated within the Schwarzschild–de Sitter era, and now not one generated in the progenitor's collapse either.

Second, there is no inflationary consistency relation: $r = -8n_t$ presupposes that scalar and tensor spectra are one vacuum stretched by one expansion, and with the amplitude not vacuum-sourced that link is absent; the substrate tensor floor is the same $\sim 10^{-122}$, so there are no substrate-sourced primordial B-modes, and any observed tensors would themselves be inherited content rather than a measure of a substrate inflationary scale. *And the tensor statement can be made unconditionally, which the scalar one cannot.* Eq. (8) was derived with $z \propto a$, which for a fluid holds only where w and c_s are constant—across the progenitor's own equality neither is.

For tensors that restriction is absent: $z_T = aM_{\mathrm{Pl}}/2$ exactly, for any content, any equation of state and any sound speed, so $z_T''/z_T = a''/a$ identically and the entire passage—background, connection, monodromy—applies verbatim with nothing assumed. It returns

$$\mathcal{P}_T \;=\; 144\pi\,(\ell_P/M)^2\rho^{-6} \;\simeq\; 5\times 10^{-111}, \tag{9}$$

evaluated at the recollapse cap and the largest composition the spectrum permits, against an observational ceiling of $\sim 7\times10^{-11}$: *below it by a hundred orders* (receipt: `P15_no_primordial_B_modes_unconditi` *So the absence of primordial B-modes is a prediction of this construction at any conceivable sensitivity, and it does not rest on the substrate's own floor*—the floor argument, like its scalar twin, ruled out the substrate's vacuum and said nothing about the progenitor's. What the crossing does to the ratio is likewise fixed and free of k: every factor of the passage is shared by the two sectors, so $r_{\rm out} = 6\,r_{\rm in}$: the passage alone would carry the ratio by 24, and the scalar mixing being twice the tensor's divides that by four in the power, and the observed bound becomes a statement about the parent, namely that its own tensor-to-scalar ratio was below 5×10^{-3}. *An observed tensor signal would therefore not falsify the construction but measure the previous generation*, which is the same reading the amplitude receives. The substrate fixes that the fluctuations are classical, inherited, and not governed by a vacuum consistency relation, and leaves their size to the handover. *What it does fix is the multiplier.* Eq. (8) holds for any incoming growing-mode amplitude, quantum or classical, so the crossing determines how much an amplitude is magnified without determining the amplitude—which is this construction's one-constant character read at the level of the perturbations rather than of the couplings. Two corollaries follow and are worth stating because each closes a natural hope in one direction and opens a statement in the other. *A_s does not measure the progenitor's mass*: with D_k free, the relation cannot be inverted, and the mass must be reached, if at all, by a route that does not run through the amplitude. And *the classical datum has a size*: since $A_s \propto D_k^2$, the parent's growing-mode amplitude must have exceeded its own vacuum's by $\sim 10^{47}$ at the top of the permitted composition window—so this cosmology does not merely decline to predict A_s, it says the previous generation's perturbations were enormously super-vacuum, which is a claim about the parent and not about us.

6 What the substrate determines: the throat and isotropization

At the branch point the near-horizon geometry is fixed, and what the perturbations cross is fixed with it.

Proposition 4 (Equal-radii $\mathrm{dS}_2\times S^2$ throat)**.** *At the Nariai locus $\Lambda G^2M^2/c^4 = 1/9$ the two positive horizon roots of $f(r) = 1 - 2GM/c^2r - r^2/\alpha^2$, $\alpha = \sqrt{3/\Lambda}$, merge at the* Nariai radius *$r_N = \alpha/\sqrt{3} = 1/\sqrt{\Lambda}$ (the symbol is the algebroid paper's [3]; it is written r_N and not $r_\star$ because r_* is the tortoise coordinate used below), where $f(r_N) = f'(r_N) = 0$ and $f''(r_N) = -2\Lambda$ (the cosmology selects this $M>0$ member of the parity-conjugate Nariai pair; the $M<0$ member has instead one positive and two negative roots, the two exchanged by $r\mapsto -r$ [5, 6]). The near-horizon geometry is $\mathrm{dS}_2\times S^2$ with both curvature radii equal to $1/\sqrt{\Lambda}$: the S^2 has two-Ricci $R_2 = 2/r_N^2 = 2\Lambda$, and the dS_2 has radius$^2 = -2/f''(r_N) = 1/\Lambda$.*

Argument. Direct from f at the Nariai mass (receipts: `verify_geometry.py`, anchor 2^{P15R9}; this is the Ginsparg–Perry near-horizon limit [28]). □

A field on $\mathrm{dS}_2\times S^2$ (Fig. 3) decomposes in S^2 harmonics; the degree-ℓ harmonic becomes a dS_2 field of effective mass $m^2 = \ell(\ell+1)/r_N^2$, i.e. $m^2/H^2_{\mathrm{dS}_2} = \ell(\ell+1)$. With the dS_2 index $\nu^2 = \frac{1}{4} - m^2/H^2$, the monopole $\ell = 0$ has $\nu = \frac{1}{2}$—a scale-invariant base—while every $\ell \geq 1$ has $\ell(\ell+1)\geq 2$, hence $\nu^2 < 0$: the heavy principal series, which oscillate and decay through the throat. We read this as an angular no-hair, and the reading is grounded rather than asserted: the dS_2 factor of the throat is a positive-Λ epoch, and the de Sitter no-hair theorem [20] damps exactly the anisotropic content—every $\ell\geq 1$ harmonic is heavy principal-series, oscillating and

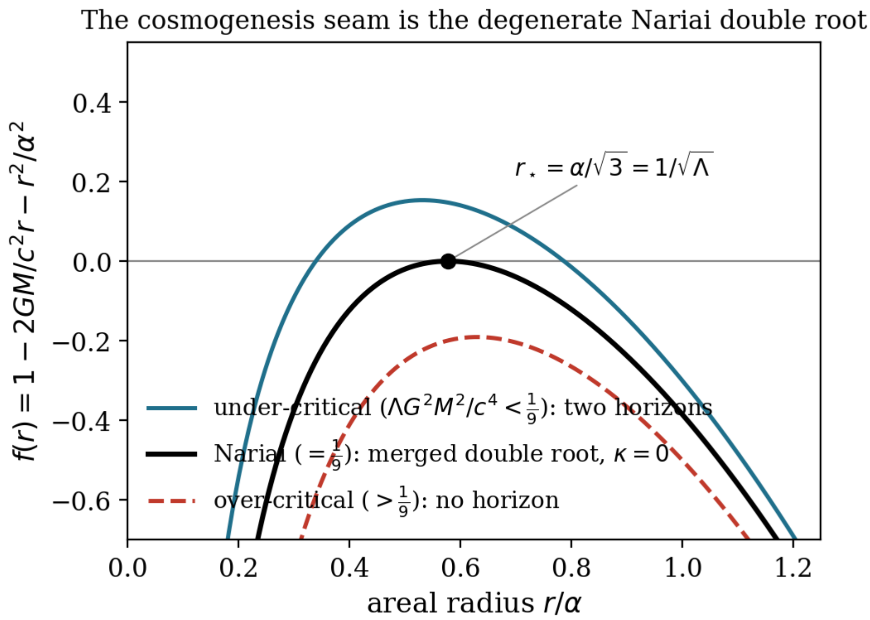

Figure 3: The Schwarzschild–de Sitter metric function $f(r) = 1 - 2GM/c^2r - r^2/\alpha^2$ across the three regimes. Under-critical masses ($\Lambda G^2M^2/c^4 < \frac{1}{9}$) give two distinct positive horizons; over-critical masses give none. The cosmogenesis branch point is carried on the *Nariai* member ($= \frac{1}{9}$), where the two horizons merge into a single *degenerate* double root at $r_N = \alpha/\sqrt{3} = 1/\sqrt{\Lambda}$ with $f(r_N) = f'(r_N) = 0$ and hence vanishing surface gravity $\kappa = 0$. The degeneracy of this root is what the throat geometry (Proposition 4) and the transmission dichotomy (§8) turn on.

decaying, while only the isotropic monopole $\ell = 0$ survives as the $\nu = \frac{1}{2}$ base—so the throat isotropizes what passes through it (receipts: `verify_throat_tower.py`[P15R33]). The geometry is established (Proposition 4) and the mode tower follows from it; the no-hair reading is the standard theorem read on the throat, and we flag one guard as load-bearing: the index ℓ of this throat tower is the S^2-harmonic degree of the *near-horizon* geometry at areal radius $1/\sqrt{\Lambda}$, and is *not* the observable microwave-background multipole, which lives on the last-scattering sphere of radius D_C. The map between them is §7, not an identity; conflating them would manufacture a prediction the geometry does not make.

7 Large scales: the flat/discrete decoupling and the low-multipole floor

Here the construction makes its sharpest large-scale statement, and the load-bearing piece is established.

Proposition 5 (The fundamental-observer slice is flat)**.** *In the fundamental-observer frame* (2)*, a surface of constant τ has induced three-metric $dr^2 + r^2 d\Omega^2$ (since $(\partial_\chi r)^2 d\chi^2 = dr^2$ along the slice), whose Riemann tensor vanishes identically. The constant-τ slice is exactly flat $\mathbb{R}^3$.*

Argument. The substitution is immediate from the line element; the curvature of $dr^2 + r^2 d\Omega^2$ is zero by direct computation (receipts: `verify_geometry.py`, anchor 1[P15R9]). This is the framework paper's own stated property that constant-τ slices are Euclidean. □

The decoupling follows. The distance slicing is the flat constant-τ one—$\Omega_k = 0$, no curvature term in the redshift–distance relation—while the *cosmological* layers are the closed S^3 of constant $\tilde{\tau} = \tau + \chi$ (§2.2). The non-synchrony $\tilde{\tau} = \tau + \chi$ is the decoupling itself: flat distances and a closed S^3 of comoving worldlines coexist because they are different slicings of one geometry. A literal closed-Friedmann reading would put $\Omega_k = -\Omega_\Lambda \approx -0.685$ into the distance relation and be excluded; CR avoids that not by tuning but because its distance slicing is the flat one, the curvature living on the orthogonal layers. Spatial curvature and dark energy are one Λ read on two slicings—the corpus identity, here at the observational rung.

The low-multipole floor. The closed S^3 carries a discrete mode spectrum, labelled by integer degree L, with comoving wavenumber $k_L = \sqrt{L(L+2)}/r_0$ and the lowest physical mode the quadrupole $L = 2$ (the monopole $L = 0$ is the background, the dipole $L = 1$ pure gauge). The decoupling fixes how these project to the sky, and the fixing is the whole point. Because the distance slicing is flat (Proposition 5), the photons are projected through the *flat* geometry—the comoving angular-diameter distance is $D_M = D_C$, the same flat-ΛCDM observable that places the acoustic scale at $\ell_A \approx 301$—while only the *source* modes carry the closed-S^3 quantization. The transfer is therefore the discrete closed-S^3 spectrum projected through the flat spherical Bessel $j_\ell(k_L D_C)$, *not* the hyperspherical transfer of a literal closed universe: that transfer carries the closed *distance* relation, which CR does not have, and would (wrongly, here) deliver the lowest mode to the quadrupole and no deficit. The flat projection places the discrete modes at

$$\ell_L \simeq \sqrt{L(L+2)}\,\frac{D_C}{r_0}, \tag{10}$$

with r_0 the present S^3 areal radius and D_C the comoving distance to last scattering, both fixed without new parameters: $D_C \approx 13927$ Mpc is the flat-ΛCDM observable and $r_0 \approx 5064$ Mpc is the Nariai amplitude $2^{1/3}/\sqrt{\Lambda}$ at the present epoch $u = \operatorname{arcsinh}\sqrt{\Omega_\Lambda/\Omega_m} \approx 1.18$. The stretch factor $D_C/r_0 \approx 2.75$—the ratio of the flat projection distance to the curvature radius, the decoupling made numerical—carries the lowest mode to $\ell_2 \approx 7.8$, with no source below it.

The full flat-projection transfer confirms the estimate and sharpens it into a prediction. Carrying the discrete spectrum through $j_\ell(k_L D_C)$ with the scale-invariant measure—the first-principles closed-S^3 Harrison–Zel'dovich weight [30, 31] $w_L = (L+1)/(L(L+2))$, fixed as the mode degeneracy β^2 (with $\beta = L+1$) times the per-mode power $1/(\beta(\beta^2-1))$ that equal power per logarithmic interval in k requires, and reducing to the continuum dk/k at large L so that $\ell(\ell+1)C_\ell$ returns to the flat plateau as $D_C/r_0 \to 0$ (receipt: `verify_lowell_exact_measure.py`[P15R22])—yields a low-multipole *deficit*: $\ell(\ell+1)C_\ell$ falls below its high-ℓ plateau for $\ell \lesssim 7$ and recovers by $\ell \approx 8$, because the flat projection of a discrete source with a hard lowest mode at k_2 leaves the lowest multipoles starved (receipts: `verify_closedS3_nonsync.py`[P15R21]).

The one effect that partly fills it is the late integrated Sachs–Wolfe term [27], sourced near the observer where small line-of-sight distances send wavenumbers $k \gtrsim k_2$—*above* the floor—down to $\ell \sim 2$.

By the decomposition of the empirical-forcing paper [11] the cumulative term is the standard Sachs–Wolfe and integrated Sachs–Wolfe—CR's own differential-expansion floor being zero under uniform expansion—so this late boost rides the same modes the discrete source keeps, and the deficit is milder than the bare Sachs–Wolfe starvation alone.

The depth is a matter for a *genuine Boltzmann transfer* rather than for the geometry, *and the reason is that the deficit is two effects and not one.* In the pure Sachs–Wolfe limit the suppression splits exactly into a *floor*—the projection integral truncated below k_2—and a *ladder coarseness*, the discrete sum minus that same truncated integral. *At $\ell = 5$ and 6 the two are comparable and pull opposite ways*: the ladder puts back power a pure cut-off removes. *And they respond to the fitted parameter with opposite signs*—under $\pm 2\%$ in r_0 the floor moves by a few per cent while the full result moves by tens—so the location is the floor and is robust for that reason, and the depth is the ladder and is volatile for that reason[12]. *The recovery multipole is the ladder's too*: with it the spectrum recovers by $\ell \approx 8$, on the floor alone not until $\ell \approx 10$. Because the only CR modifications are the discrete source and the flat projection—every transfer ingredient (Sachs–Wolfe, early and late integrated Sachs–Wolfe, Doppler) shared with

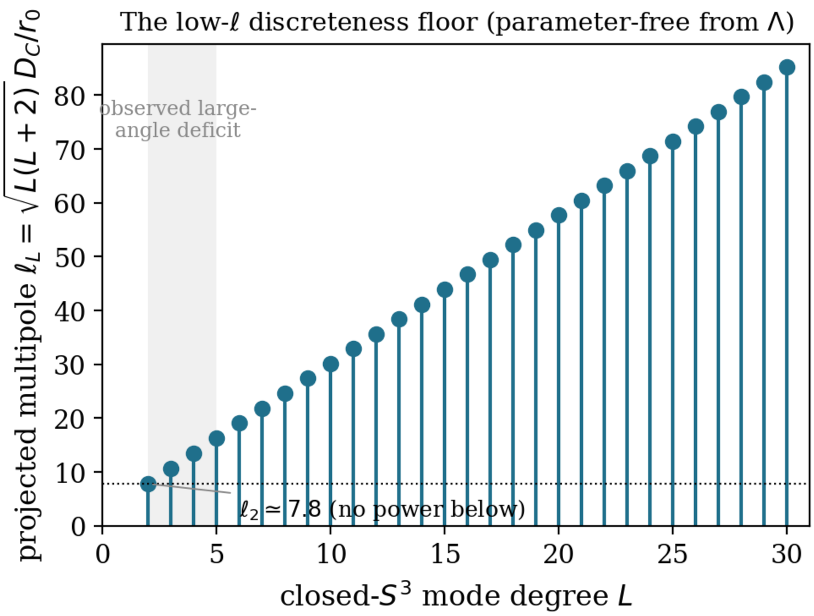

Figure 4: The low-multipole discreteness floor. The closed-S^3 source spectrum is discrete ($k_L = \sqrt{L(L+2)}/r_0$, lowest physical mode $L = 2$), but the flat distance slicing (Proposition 5) projects it through the *flat* transfer $j_\ell(k_L D_C)$, not the hyperspherical transfer of a literal closed universe. With $D_C \approx 13927$ Mpc and $r_0 \approx 5064$ Mpc fixed parameter-free by Λ, the stretch $D_C/r_0 \approx 2.75$ carries the lowest mode to $\ell_2 \approx 7.8$, with no source below it. The full flat-projection transfer turns this into a low-multipole power deficit ($\ell \lesssim 8$); on a genuine Boltzmann transfer (the late integrated Sachs–Wolfe sourced above the floor and so retained by the discrete source) it sits at 0.473, 0.410, 0.356, 0.676 of the flat-ΛCDM expectation at $\ell = 2, 3, 4, 5$, recovering by $\ell \approx 8$—*a deficit whose minimum falls at* $\ell = 4$, so that the quadrupole and octopole are its shoulders and not its floor. Those figures are the first arm, read through CAMB's exact $\Delta_\ell(k)$; the photon hierarchy built for this programme (§9.1) is the second arm and returns 0.49, 0.24, 0.18, 0.61, agreeing on the shape and not on the depths (§7); an independent transfer, this cosmology's discrete source read through a standard Boltzmann code's own $\Delta_\ell(k)$, gives 0.49, 0.24, 0.18, 0.61 at the same multipoles—close at the quadrupole and nearly a factor two apart at $\ell = 3$ and 4, with *the same* minimum at $\ell = 4$ and the same recovery. *The shape is cross-validated between the two; the depth is not.* Either way this is a mild deficit, non-discriminating against the observed large-angle power within the lowest multipoles' cosmic variance (shaded). The location is geometric and robust; the depth is whatever the full Boltzmann transfer returns, and the two run here differ on it. *What the branch-point filter does to this prediction at these multipoles—and what it does not do—is taken up in the text below rather than here.*

flat-ΛCDM [11]—the exact CMB temperature transfer $\Delta_\ell(k)$ of a standard Boltzmann code *is* CR's transfer, and the discrete spectrum is read off it: $C_\ell^{\mathrm{CR}} = \sum_{L\geq 2} w_L\, \Delta_\ell(k_L)^2$ against the continuum $\int d\ln k\, \Delta_\ell(k)^2$, the measure w_L being exactly $d\ln k_L/dL$ so the CR sum is the L=2-floored Riemann sum of the very integral ΛCDM does continuously.

Carried out with the exact transfer (gate-validated: the continuum reproduces the code's own C_ℓ to four figures; and the r_0 sensitivity is measured rather than assumed: the *shape* is stable—the minimum stays at $\ell = 4$ and the recovery multipole moves by 0.1%—while the *depths* drift by up to 15% at $\ell = 4$ under ±2% in r_0), the deficit is *milder* than a Sachs–Wolfe-only estimate suggests, and it has a shape: $\ell(\ell+1)C_\ell$ sits at ≈ 0.47, 0.41, 0.36 and 0.68 of the flat-ΛCDM expectation at $\ell = 2, 3, 4, 5$, recovering by $\ell \approx 7$ (receipt: `verify_lowell_boltzmann.py`[P15R24]). *The prediction is therefore not a monotone recovery from the quadrupole but a dip whose minimum falls at* $\ell = 4$[P15R27]—and the quadrupole and octopole, the two multipoles a large-angle discussion reaches for first, are its two *shallowest* points.

The shape is not one code's, and that was checked here by running it rather than by comparing tables[P15R29].

Driving the photon hierarchy built for this programme (§9.1) through the same discrete projection puts the minimum at the same multipole, $\ell = 4$, and recovers at the same place, $\ell \approx 7$–8. *What two independent Boltzmann treatments cross-validate is the shape, and only the shape.* The depths do not agree: the second arm returns 0.49, 0.24, 0.18 and 0.61 against the first's 0.473, 0.410, 0.356 and 0.676—close at the quadrupole and nearly a factor two apart at $\ell = 3$ and 4. The two treatments differ in their late-time integrated Sachs–Wolfe handling and in D_M, and this paper does not reconcile them: it carries one converged depth table, the first arm's, and a second arm that agrees on where the deficit sits and not on how deep it is.

The reason is the late integrated Sachs–Wolfe: it is sourced near the observer at wavenumbers $k \gtrsim k_2$ (small line-of-sight distances), *above* the floor, so the discrete source *retains* it rather than losing it, and the deficit is milder than a Sachs–Wolfe-only treatment of the same source would give.

This is a parameter-free deficit, set by Λ through r_0 and D_C, and what is robust is its existence, its location ($\ell \lesssim 8$, geometric, set by $k_2 D_C$), its minimum at $\ell = 4$, and that the single floor k_2 starves $\ell = 2$ and $\ell = 3$ *together*: the exact discrete measure and the Doppler term (super-horizon velocity through j'_ℓ) each leave the $\ell = 2$-to-$\ell = 3$ ratio near unity, if anything suppressing the octopole slightly more (receipts: `verify_lowell_exact_measure.py`[P15R22], `verify_doppler_lo` Coherence shown is not correspondence earned: whether this predicted deficit matches the observed sky is the data test, against the large cosmic variance of the lowest multipoles. Confronted with the measured low multipoles, the honest verdict is a *wash.* CR predicts a smooth modest deficit bottoming at $\ell = 4$; the observed sky has a sharp quadrupole-only dip (~ 0.2) with a near-ΛCDM octopole (~ 0.6–1.0), so CR sits *above* the observed quadrupole and *below* the observed octopole, matching neither sharply. Under the exact cosmic-variance likelihood the net over $2 \leq \ell \leq 10$ is $\Delta(-2\ln L) \approx +1.8$ (range $+0.3$ to $+3.8$ across the octopole estimator), a small residual well inside cosmic variance (receipts: `confront_lowell_data.py`[P15R25], `verify_lowell_likelihood_v2.py`[P15R26]). *Broken up by multipole, the sector's weight does not lie where its name suggests*: the quadrupole *rewards* this cosmology (-2.6, its milder dip nearer the observed low power than flat ΛCDM's), the octopole penalises it at $+1.3$, and the largest single-multipole penalty is the $+2.1$ at $\ell = 4$—the prediction's own minimum, and the one multipole of the four that the large-angle literature does not treat as anomalous. The low multipoles are thus a genuine but *non-discriminating* sector: neither a parameter-free correspondence success nor a sharp falsification edge, but a mild deficit consistent with ΛCDM within the lowest multipoles' cosmic variance.

One further caveat belongs with this prediction, and it is not a general disclaimer but a located one. The branch-point filter that sets what crosses into the expansion leg is, in its quantum reading, a Euclidean kernel whose action on a mode is controlled by an adiabaticity parameter C/μ_n, with μ_n the harmonic index of the layer's S^3 tower [34]. That parameter is small for all but the lowest harmonics and reaches order unity only at $n = 2$ and $n = 3$, where it takes the values 0.70 and 0.47. *Three independent routes place the filter's loss of control at the same scale*: the transmission calculation's boundary at $\ell \approx 2.5$, the projection's incompleteness below $k \sim 2 \times 10^{-4}\,\mathrm{Mpc}^{-1}$ ($\ell \approx 3$), and this breakdown at $n = 2, 3$.

The transmitted amplitude at low multipoles can be computed rather than estimated, and doing so settles what the estimates left open. The branch-point filter's action on a mode is, in the quantum reading, a Euclidean kernel [34]. The exponential-of-an-integral form $e^{-\int \omega\,\mathrm{d}\eta}$ is a WKB approximation whose adiabaticity parameter is of order unity at $\ell \lesssim 5$; but the underlying mode equation $\mathrm{d}^2\psi/\mathrm{d}\eta^2 = \omega^2\psi$, with $\omega = kc_s$ and $\mathrm{d}\eta = \mathrm{d}s/a$ along the segment, is well posed at every k, and integrating it is a matter of numerics rather than of approximation. Composing exact constant-ω transfer matrices in the stable direction over the segment ($|\Delta\eta| = 3.32$ in units $\alpha = 1$) gives exact/WKB ratios of 0.926, 0.913, 0.901, 0.891 and 0.889 at $\ell = 2, 3, 5, 15, 40$: *the WKB form is accurate to* 7–11% *at every multipole from* 2 *to* 40, with the exact transmission slightly smaller, so the filter is marginally stronger than the approximation gives.

Two readings suggested by the adiabaticity parameter alone are thereby excluded. The first is that the treatment is uncontrolled at $\ell = 2$–5: it is not, and the parameter was the wrong figure of merit, measuring as it does the fractional error in an exponent that is itself small at low ℓ. *The residual's own behaviour settles this independently of any argument about the parameter*: the ratio *decreases* monotonically with ℓ—0.926, 0.913, 0.901, 0.891, 0.889—so the discrepancy is smallest at $\ell = 2$, where the adiabaticity parameter is of order unity, and largest at $\ell = 40$, where it is small. An error of adiabatic origin runs the other way, WKB being an expansion *in* that parameter, so such an error is largest where the parameter is $O(1)$ and vanishes as it does. *What the numbers show is therefore a systematic offset rather than an adiabatic breakdown*—the WKB form is uniformly slightly generous and the exact filter uniformly slightly stronger, which is a correction of known sign and bounded size and not a loss of control[L19]. The second concerns the comparison with the observed sky. The correction is very nearly ℓ-independent—varying by 4% across a factor of twenty in ℓ—so between $\ell = 2$ and $\ell = 3$ it alters their ratio by 1.4%. *The structural expectation that a single floor starves $\ell = 2$ and $\ell = 3$ together is therefore not relieved by the exact treatment*, and the observed sky's selective suppression of $\ell = 2$ alone, by a factor of order three, remains unaccounted for. The low-multipole prediction of this section therefore stands as stated, and so does the discrepancy it faces.

Finally, the two Boltzmann depths above are not rival claims and neither supersedes the other: they differ by up to a factor of two at $\ell = 3$ and 4 and agree on the shape, the minimum and the recovery, and the difference is the size of the residual §9.1 declares. What both supersede is the Sachs–Wolfe-analytic estimate (0.22 and 0.20 at $\ell = 2, 3$), which takes the Sachs–Wolfe source as the matter-domination value $\frac{1}{3}\Phi$, whereas at recombination $\rho_r/\rho_m = 0.317$ and the source is $0.4006\,\Psi$—a 20% error in the very ratio of Sachs–Wolfe to integrated Sachs–Wolfe that fixes how much the latter fills the bare deficit.

8 What the progenitor supplies: the transmission proof

The decomposition's decisive proof is here: *why* the substrate transmits the spectral shape rather than imprinting one of its own. It turns on the degeneracy of the *Nariai double root*—the front seam at $r = +\alpha/\sqrt{3}$, where f and f' vanish together so that $\kappa = 0$. *That locus is not the branch point*: the branch point sits at $r = 0$, carries no surface gravity because f diverges there rather than vanishing, and is not a Killing horizon at all.

Proposition 6 (Transmission dichotomy)**.** *For a mode approaching a horizon where the metric function behaves as $f \sim (r - r_h)^p$, the tortoise coordinate $r_* = \int dr/f$ controls the approach. At a non-degenerate horizon ($p = 1$, $f \sim 2\kappa(r - r_h)$, surface gravity $\kappa > 0$) the integral is logarithmic and the approach exponential, $(r - r_h) \sim e^{2\kappa r_*}$. At the degenerate Nariai double root ($p = 2$, $f \sim -\Lambda(r - r_N)^2$, $\kappa = 0$) the integral is $r_* \sim +1/[\Lambda(r - r_N)]$ and the approach power-law, $(r - r_N) \sim +1/(\Lambda r_*)$.*

Argument. The two tortoise integrals directly (receipts: `verify_geometry.py`, anchor 4[P15R9]). □

Remark 1 (The leg does not tilt it either)*.* The proposition argues from the *front seam*: a degenerate Killing horizon carries no scale, so it cannot imprint one. The collapse leg supplies the other half of the same conclusion, by an independent route. Horizon entry on that leg occurs at $x = k\eta/\sqrt{3} = 1/\sqrt{3}$ *for every k*—the radiation era's own scale invariance, which §4.1 recovers from the substrate geometry—so every mode leaves the leg carrying the same free-oscillation amplitude $\Psi(1/\sqrt{3})/2 = 0.4835\,\Psi_i$, a single k-independent number[P15R34]. *So the leg multiplies the spectrum by a constant and the branch point imprints nothing*: neither carries a scale, and a spectrum can only be tilted by something that does. The tilt observed is therefore the progenitor's, established now from both sides of the branch point rather than one.

"Carries a scale" has an operational form, and it is worth recording because it is what makes the dichotomy testable rather than descriptive: a kernel carries a scale exactly when the tilt one fits to it *depends on which band one fits.* Fitted on four disjoint bands, the degenerate ($p = 2$) kernel returns one tilt to sixteen decimal places while the non-degenerate ($p = 1$) kernel spreads by several units, and that spread shrinks as κ grows—a larger scale pushing its knee past the range. Restoring a scale to the degenerate kernel by hand destroys the agreement, so the scale-freedom is doing the work and not the arithmetic[P15R143L21]. *This restates Proposition 6 and proves nothing further*; what it adds is a test one can run on a kernel without knowing where it came from.

Remark 2 (What the branch point does not fix)*.* Both halves of the dichotomy are statements about the spectrum's *shape*: a degenerate horizon carries no scale, and neither does horizon entry on the leg, so neither can tilt what passes. *Neither is a pointwise condition on the perturbation state at the branch point*, and the distinction matters for anyone computing the handover. The single free function per mode is the freedom of the *spectrum*—the progenitor's amplitude and tilt—not a claim that the branch point fixes the state component by component. The state itself is whatever the leg's evolution produces, and §4.1 supplies it in closed form: the potential from the leg's own equation, the effective temperature oscillating freely from horizon entry, and the density contrast as their difference.

The Hamiltonian constraint is not an additional condition to impose there. In this framework it *is* the anchor—the map from a cut to its stress-energy, whose energy sector reads the Friedmann equation off the geometry [7, 8]. It is a definition, not a restriction: on the leftward reading the rate is set by the substrate and the content is read from it, so the perturbed constraint likewise *defines* the density contrast a given geometry carries rather than restricting which geometries are allowed. Imposing it at the branch point alongside the leg's own solution therefore over-determines the handover, and the same geometric state answering to different stress-energy on the two sides is not a failure of matching but the branch point doing what the level assignment says it does.

Remark 3 (What the branch point's degeneracy does not settle)*.* It is tempting to read Proposition 6 as settling the phase as well as the shape: the tortoise coordinate diverges at the degenerate root, so a mode's accumulated phase would be unbounded and nothing finite could be inherited. *That reading does not survive its own arithmetic.* The divergence is geometric and carries no k, so an unbounded kr_* is a divergent term *linear* in k; a linear phase renormalizes the sound horizon rather than shifting the comb, and an unbounded one would send the comb spacing to zero and erase the acoustic peaks altogether—excluded by observation, not supported by it. And the modes never meet the divergence in any case: they cross the branch point at finite conformal time, whereas r_* diverges along a static slicing's approach to the horizon, which is not the collapse trajectory.

What the leg does contribute is finite and, as it happens, invisible in the peak positions. Horizon entry at $x = 1/\sqrt{3}$ for every k makes the accumulated leg phase $k\eta_{\text{bp}}/\sqrt{3} - 1/\sqrt{3}$: linear in k with a mode-independent offset. So carrying it across rescales the effective sound horizon by $1 + \eta_{\text{bp}}/(\sqrt{3}\, r_s)$ and adds a constant, and changes the comb in no other way. *The comb therefore cannot distinguish a transmitted phase from a reset one*, because a rescaling of r_s is degenerate with the onset redshift that §4.7 fixes from the acoustic angle. Any discriminant must be a quantity that does not take the same factor—the diffusion scale is one, since r_D does not—and that is the discriminant of principle. *The comparison is now made, and it does not require r_D.* The leg's accumulated conformal time is fixed by the geometry rather than fitted: the collapse branch $r = -(2M\alpha^2)^{1/3} \cosh^{2/3}(3\,\text{Re}\,\tilde{\tau}/2\alpha)$ has $\cosh \geq 1$, so $|r| \geq (2M\alpha^2)^{1/3} = 3766.6$ Mpc and the branch point is reached only across the lift, along which $\text{Re}\,\tilde{\tau}$ does not advance and no conformal time accumulates. Hence $\eta_{\text{bp}} \approx 5 \times 10^3$–$10^4$ Mpc, and $r_s^{\text{eff}} = r_s + \eta_{\text{bp}}/\sqrt{3}$ is *dominated* by the leg term—3.0–5.9 $\times\, 10^3$ Mpc against $r_s = 144$ Mpc. The degeneracy with the onset redshift, which absorbs a small rescaling, cannot absorb this one: reproducing the

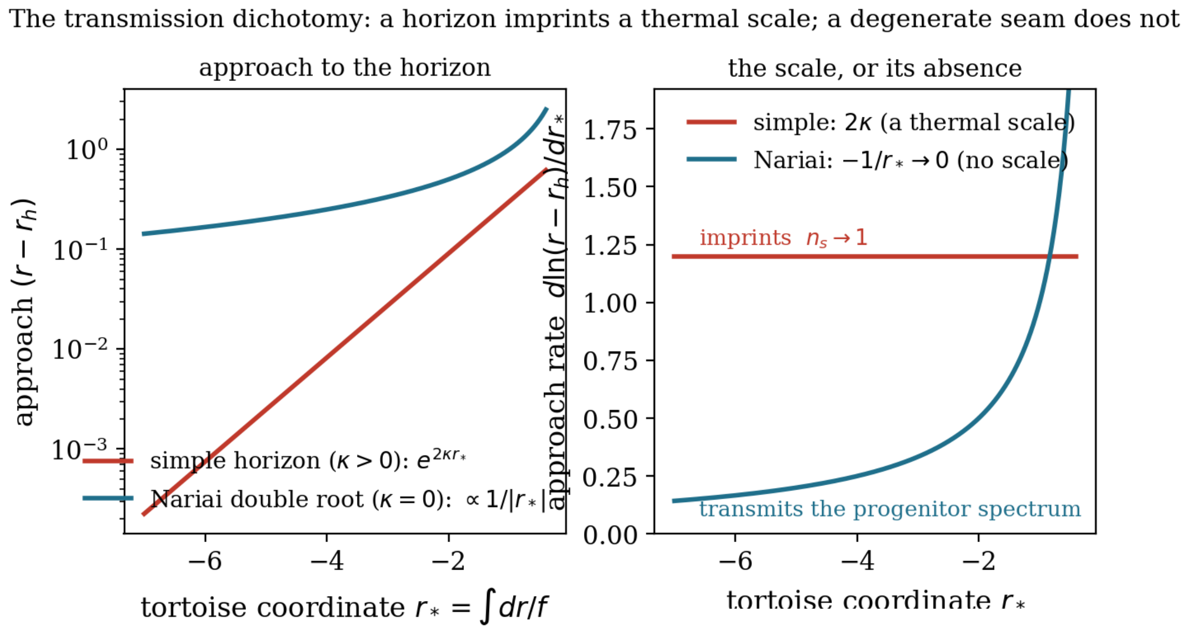

Figure 5: The transmission dichotomy (Proposition 6). *Left*: the approach to the horizon in the tortoise coordinate $r_* = \int dr/f$, on a logarithmic vertical axis. At a non-degenerate horizon ($\kappa > 0$) the approach is exponential, $(r - r_h) \sim e^{2\kappa r_*}$ (a straight line); at the Nariai double root ($\kappa = 0$) it is power-law, $(r - r_N) \sim 1/|r_*|$. *Right*: the logarithmic approach rate $d\ln(r - r_h)/dr_*$ *is* the local scale. The non-degenerate horizon carries a fixed thermal scale 2κ—the mechanism by which a de Sitter horizon imprints a scale-invariant spectrum ($n_s \to 1$); the branch point's rate falls to zero, carrying *no* scale, so it transmits the progenitor spectrum unaltered.

measured $\ell_A = 301.8$ would require $D \approx 2.9$–5.7×10^5 Mpc against the actual 1.4×10^4 Mpc, a factor of 21–41. *The acoustic phase is therefore reset at the branch point and not carried across it*—established on the peak positions alone[P15R35]. The result is robust to the open account of the lift: any conformal contribution the lift is found to carry only adds to an already-excluded total.

The amplitude separates from the tilt in the same statement. What the progenitor supplies is the potential power P_Ψ; what the construction contributes is the factor $(0.4835)^2 = 0.2338$ carrying it to the observed A_s. That factor is computed rather than fitted, so the accommodation is narrower than it was—the inherited quantity is P_Ψ and the map from it is derived—but it is not removed, and the framework paper's scoping of this as a one-parameter accommodation stands unchanged [9].

The physical reading is the result (Fig. 5). The exponential, non-degenerate approach is the thermal (Hawking) law—the mechanism by which a de Sitter horizon *imprints* a scale-invariant spectrum ($n_s \to 1$): the exponential redshift erases the infaller's spectral information and stamps the horizon's own thermal scale. The power-law, degenerate approach carries no thermal scale; it is scale-free, and the infalling spectrum is transmitted faithfully. CR's transmission locus is the branch point $r = 0$, where f *diverges* as $-2M/r$ so the tortoise coordinate is *finite*—the crossing accumulates no divergent phase and stamps no scale, a third case beyond the dichotomy's two[P15R35]. The Nariai double root (Proposition 4, $f''(r_N) = -2\Lambda$, $\kappa = 0$) is the *equatorial seam*—one point of the substrate, which the bead meets on the way in and again one full lap later, the two chart values $r = -2\alpha/\sqrt{3}$ and $r = +\alpha/\sqrt{3}$ being the same φ modulo 2π in the phase $\varphi = 2\pi r/\sqrt{3}\alpha$. The branch point sits two thirds of the lap in from it (240°, with 120° remaining), so the crossing at $r = 0$ and the seam are distinct loci on the lap without the seam being an endpoint of anything. Hence:

Proposition 7 (The branch point transmits)**.** *The cosmogenesis branch point is a faithful scale-free transmitter—not because it* is *the degenerate Nariai horizon, which it is not (that is the front seam, $r = +\alpha/\sqrt{3}$, the lap's other endpoint), but because f there* diverges *as $-2M/r$, so r_* is finite and the crossing accumulates no divergent phase at all: the amplitude A_s and tilt n_s are the progenitor collapse's spectrum carried across unaltered, not imprinted by the branch point. Equivalently, CR has no inflationary scale-invariant attractor, because the non-degenerate exponential approach that would drive $n_s \to 1$ is exactly the approach the Nariai seam does not have.*

The degeneracy is thus the proven reason CR carries the primordial tilt rather than manufacturing it. What the transmitter carries is, from the Schwarzschild–de Sitter side, open: n_s and A_s are inherited, fixed by the progenitor collapse—the same handover that fixes ρ_r/ρ_m and the light-element abundances—and not derived here. *Naming them together is convenient and has concealed that they are not the same kind of quantity*[P15R78]. The vacuum normalisation is the only place a quantum constant enters the spectrum, so $P(k) = \hbar A_0 k^{n_s-1}$ and $\hbar$ is an overall multiplicative factor: *it survives in the amplitude and cancels in every logarithmic derivative.* An amplitude is the spectrum at one wavenumber; a tilt is its ratio to itself at two. *So the construction's inability to force a dimensionless magnitude bears on A_s and not on n_s*—the first is permanently inherited, the second need not be. *And read backwards the same statement is useful rather than limiting*: a quantity fixed by the moduli rather than the invariants is one the observation *measures*, so the observed A_s determines the progenitor's mass, to be checked against the independent requirement that it lie below the Nariai value. *And it is worth saying precisely what that openness is, because a count settles its kind.*[P15R77] The progenitor family described here is parametrised by M alone—α is the one invariant and $E = 1$ a choice of geodesic—so the geometry is one-dimensional; and the Kretschmann along the bead is mass-free in the faller's own proper time, so that one parameter does not survive the approach either. *A quantity identical for every member carries no information about which member it was*, and the collapse geometry therefore transmits not one parameter but none. Against that stand at least four independent inherited numbers. *So 'inherited from the progenitor collapse' cannot mean inherited from the collapse geometry*: what is inherited is inherited from the progenitor's matter content—its composition, its entropy per baryon, its perturbation spectrum—and none of that is carried by M, the exterior here being exactly vacuum and the marginally-bound interior dust without composition. *The frontier is accordingly not a derivation awaiting a cleverer argument but a modelling task awaiting a progenitor interior*, and what the geometry supplies in its place is a cutoff rather than a content: the segment's conformal length $|\Delta\eta| = 3.32\alpha$ is fixed by Λ alone *on the Nariai member*—below it $|\Delta\eta|$ runs as $M^{-1/3}$, reaching 4.19α at $M/2$ and 15.4α at $M/100$—and says which modes survive without saying how large they were.

9 Predictions, and the progenitor boundary

The signatures, with their maturity marked:

1. Classical, non-vacuum primordial statistics; no inflationary consistency relation; no substrate-sourced primordial B-modes (established, §5).

2. The transmission character: the branch point carries the progenitor tilt and does not drive $n_s \to 1$ by any *inflationary* attractor (established, §8). *Nor does the construction lack a scale-invariant attractor—it has one, and it is not the inflationary root.*[P15R74] Scale invariance for a background $a \propto (-\eta)^\beta$ with $z \propto a$ requires $\beta(\beta - 1) = 2$, a quadratic with *two* roots: $\beta = -1$, de Sitter inflation, and $\beta = +2$, a matter-dominated contraction. *The collapse leg of this construction is the second root exactly*: near the branch point $f \to -2M/r$, so the leg is pressureless there and the banked law $r^3 = \frac{9}{2}M\tau^2$ with $a = |r|$

gives $a \propto \tau^{2/3} \propto \eta^2$; the mode equation integrated from vacuum data returns a flat spectrum to a part in 10^4. *The mode-selection question that shadows this in the literature was accordingly put to the construction directly, and it answers in the negative.*[P15R75]

The scale-invariant spectrum sits in the mode that *dominates* the contraction, whose curvature perturbation goes as η^{-3}; the mode that survives on the expanding side is the constant one, and from vacuum data its spectrum is $n_s - 1 = 6$.

Whether the first reaches the second is a connection problem at the branch point, and here it is settled rather than assumed: the exponents 2 and -1 differ by an integer, so a logarithm could mix them, but the $\sinh^{2/3}$ law is *even* in τ, which in conformal time places its correction at η^6 and steps the Frobenius recursion in sixes past a resonance sitting at three. *No logarithm is generated, the continuation acts diagonally, and the scale-invariant spectrum does not reach the observer*—confirmed independently by continuing the dominant solution numerically around the branch point, where the admixture it produces is what the claim turns on, where the admixture falls as $\delta^{2/3}$ and the diagonal entry goes to unity. *What survives is therefore narrower than it first appeared and sharper than what it replaced*: the construction *has* a scale-invariant background, the spectrum that background freezes is confined to the contracting side, and the obstruction is a parity property of the construction's own solution rather than a missing mechanism. *Mixing would require a background correction odd in τ, and that question is settled here too, in the negative.*[P15R76]

Writing the law as $r = Au^{2/3}g(u)$ with $g = [\sinh u/u]^{2/3}$ places every branched factor in $u^{2/3}$ and leaves g even, analytic and non-vanishing at the origin—exactly, since $\log(\sinh u/u)$ is analytic in u^2 there and the exponential of a series in u^2 is one. The three sheets differ by a constant cube root of unity, and a constant multiplier cannot change a parity; the conjugate branch is even as well, and carries no branch point at all. *So the evenness is unavoidable, and what it says is not a technical fact but a symmetry*: $r(-\tau) = r(\tau)$, the cosmogenesis is time-symmetric about the branch point, and a time-symmetric background cannot mix a growing mode with a decaying one, since mixing would distinguish a direction of time the background does not. *The same invariance is already load-bearing one observable over*—the peak heights of §5 follow from a driving amplitude exactly invariant under time reversal, which is why they may be evaluated on the contracting side. *One symmetry, two consequences. And it locates rather than forecloses what would be needed*: this leg is exactly even because it is the marginally-bound geodesic of an exactly vacuum exterior, so a progenitor carrying real matter content—pressure, dissipation, anything with an arrow—would not be, which returns the question to what the progenitor was.

3. Flat distances ($\Omega_k \simeq 0$) coexisting with a closed-S^3 low-multipole *deficit* below $\ell \approx 8$, set parameter-free by Λ—mild, and on a genuine Boltzmann transfer a dip bottoming at $\ell = 4$ (≈ 0.47, 0.41, 0.36, 0.68 of the flat-ΛCDM expectation at $\ell = 2, 3, 4, 5$), its shape cross-validated between two independent transfers (*established* for the existence, the location and the minimum; *open* for the depth, on which the two transfers differ by up to a factor of two at $\ell = 3$ and 4 (§7); *non-discriminating* as a test, the deficit sitting inside the largest multipoles' cosmic variance). Confronted with data it is non-discriminating: it starves $\ell = 2$ and $\ell = 3$ together, matching neither the sharp observed quadrupole-only dip nor the near-ΛCDM octopole, and sits consistent with ΛCDM within the lowest multipoles' cosmic variance (§7).
4. Coherent acoustic peaks from geometric (null-boundary) phase-fixing rather than superhorizon freeze-out (argued, §4).
5. The acoustic scale is resolved in the cosmological development above (§2.3), and the

geometric rate (4) is the standing CR-versus-ΛCDM discriminator on data in hand (*established*, §2.3)—a strength established before the spectrum, not this section's to re-assert.

The boundary is principled. The substrate carries everything the branch point's null geometry lets it carry—coherence, isotropization, the discreteness floor, the classical character, the faithful transmission—and the degeneracy proves precisely where it stops: the spectrum's amplitude and tilt are not the substrate's to set. This is the shape inflation has when it parametrizes its observables through an unknown inflaton potential; CR routes them through an unknown progenitor collapse, with the arrival constrained—whatever the collapse supplies must reach the branch point coherent, isotropized, scale-freely transmitted, and classical.

The symmetry between the two unknown suppliers is only apparent, and the asymmetry is the substance. Inflation is not structure the standard cosmology already contains; it is an added sector—a scalar field with a freely specified potential—introduced to produce features that cosmology was known to lack: the causal contact the horizon problem denies, the flatness the dynamics do not single out, and, once these were in view, a near-scale-invariant spectrum. The potential is then chosen to deliver the observed amplitude and tilt. A model built to be tunable, and tuned to a target known in advance to require tuning, earns precisely what such a model can earn—it establishes that the features are *possible*, that an apparatus permitting them exists. It does not establish that they were *required*, and the routine elevation of the spectral fit into a vindication of inflation conflates the two: that a freely chosen potential can be set to match n_s and A_s is not evidence that inflation occurred, but the statement that a model with enough adjustable structure to fit has been fit. This is the distinction between a world that *requires* a phenomenon and one that merely *permits* it through adjustable parameters—the same distinction the programme draws in reading the cosmic foliation as forced rather than chosen [11]—and it places the inflationary spectrum on the permitting side.

The present cosmology adds no such apparatus. Causal contact, isotropy, flatness, phase coherence, and scale-free transmission are not produced by a field introduced to produce them; they are read off structure the construction already contains—the de Sitter throat that isotropizes by the no-hair theorem (§6), the null boundary on which coherence *is* the characteristic-data condition (§4), the exactly Euclidean constant-time slice (§2.3), and the degenerate horizon whose vanishing surface gravity transmits rather than imprints (§8)—each fixed by Λ alone, with no parameter free to do the producing. The one quantity it does not derive, the amplitude and tilt, it inherits in exactly the sense flat ΛCDM inherits the baryon-to-photon ratio; on that single datum the two frameworks stand level, and on everything the inflationary sector is invoked to supply they do not. The verdict this licenses is not symmetric, and it does not await a future measurement. On the data in hand the two align; on the structure each must assume in order to align, one introduces an entire tunable sector and tunes it while the other introduces none—and makes, in its place, falsifiable commitments where inflation keeps its freedom: no scale-invariant attractor *reaching the observer*, no consistency relation, no substrate-sourced B-modes (§5, §8)[P15R75]. By the economy of assumption that distinguishes a required structure from a permitted one, that comparison is settled now, by what each theory must presuppose, and it is settled in this cosmology's favour. We hold this at its weight and mark its bound in the same breath: the parsimony verdict is earned, and the data verdict has now begun to be earned with it—the Hubble tension resolved across the distance ladder where ΛCDM cannot reconcile the direct H_0 (§2.4), the abundances confirmed within 1σ [18]—so the cosmology is empirically favoured, not merely more economical; the spectrum's content remains inherited, and the large-angle shape remains the exposed edge that could still overturn it.

9.1 The acoustic instrument: what it is validated against, and to what accuracy

The low-multipole prediction above and the ratio statements below are carried by a Boltzmann transfer built for this programme, and its standing should be stated plainly rather than assumed. It is a full photon hierarchy with polarisation, second-order tight coupling, massless neutrinos, and a Peebles recombination history; the line-of-sight source carries the monopole with the potential, the Doppler term, the integrated Sachs–Wolfe term, and the quadrupole with its own projection kernel ($j_\ell + 3j_\ell''$).

Against a like-for-like reference—an independent Boltzmann code run at identical parameters, unlensed and with reionisation off—it reproduces the *acoustic peak and trough positions to* $\leq 0.5\%$ across P_1–P_4, the *ionisation history* $x_e(z)$ *and its derivative to* $\sim 1\%$ through the visibility peak, matter–radiation equality to 0.02%, and the *transfer function to better than* 1% *for* $k < 0.02\,\mathrm{Mpc}^{-1}$. Above that wavenumber it agrees to 1–2%, with the residual scatter in both directions and no trend across the range[P15R36].

Two construction details are worth stating, because both are easy to omit and both have signatures that read as physics.

The first is the reach of the mode ladder. The angular spectrum at multipole ℓ is an integral over wavenumber, and the projection kernel $j_\ell(k(\eta_0 - \eta))$ has substantial support *above* $k = \ell/D_M$, not merely at it; a ladder cut at $k_{\max}$ therefore truncates the integral, and does so more severely as ℓ rises toward $k_{\max}D_M$. Quantitatively, truncating an exact transfer at $k_{\max}D_M = 900$ retains 99.2% of C_ℓ at $\ell = 200$ but only 61% at $\ell = 800$ and nothing at all at $\ell = 1150$; carrying the ladder to $k_{\max} \geq 2\,\ell_{\max}/D_M$ recovers every multipole to better than half a per cent. *The tell is unmistakable once known*: the highest peak simply fails to appear, so a spectrum that should show four acoustic peaks shows three, and the peaks that do appear are displaced downward by an amount that grows with ℓ. *Increasing the ladder's density at fixed reach does not help*—the loss is the range, not the sampling, which is worth checking explicitly because the two are easily confused.

The second is the seeding of the conformal time. It is a cumulative integral, $\eta(a) = \int_0^a \mathrm{d}a'/(a'^2 H)$, and a numerical grid necessarily begins at some finite $a_{\min}$; the interval already elapsed below that point must be carried as a seed rather than set to zero. In radiation domination $H \propto a^{-2}$ makes the integrand constant, so the omitted piece is $a_{\min}/(H_0\sqrt{\Omega_r})$ exactly—for $a_{\min} = 10^{-5}$ it is 4.6 Mpc. *It is a fixed offset at every epoch*, and therefore 0.03% of η_0 but 12% of η at $z = 10^4$: the acoustic scale, the peak positions and the peak ratios are insensitive to it, while any early-time quantity or any comparison against a second code is not. Its signature is instructive—because the potential decays more steeply at larger k, a fixed error in the time coordinate reads out as a *smooth, monotone, k-growing* error in amplitude, which is the shape one would otherwise attribute to a physical suppression. The grid must also extend below the intended starting redshift, so that the initial epoch is interpolated rather than clamped.

That residual does not enter the claims made here. The Cosmological Relativity and flat-ΛCDM spectra are computed through the *same* machinery, so an instrumental transfer error afflicts both arms identically and cancels in their ratio—and every prediction stated in this paper is a ratio. The low-multipole deficit in particular lives at $\ell \lesssim 8$, i.e. $k \ll 0.02\,\mathrm{Mpc}^{-1}$, where the two agree to better than 1%. What the residual does forbid is an *absolute* amplitude claim: this instrument should not be read as reproducing the observed small-angle power to better than a few per cent, and no such claim is made.

10 The open frontier: the pieces this cosmology is built to close

The result stands on what the substrate determines. What it does *not* yet claim has been carried to a sharp, gradable edge rather than left vague—and those edges are the most interesting part of the programme from here, each a gap we are eager to grind shut, not paper over.

We hold them to the criterion of necessity the programme's epistemology names—that a structure is credited for *requiring* a phenomenon, not for *permitting* a value that fits it [12]—and sort them by it: a gap that is *buildable* is a debt owed, to be built before the claim it bears on is a proof rather than a coherent proposition, while a genuinely external unknown may stay open at no cost, exactly as flat ΛCDM leaves its own inherited data open.

The buildable ones below are named as debts, not softened into frontiers. *Of the four, one remains owed and three are run*: the end-to-end branch-point-to-recombination transfer is the load-bearing debt; the large-angle depth and the low-multipole likelihood are built and confronted below; and the derivation of the progenitor spectrum is the genuine frontier rather than a debt. Four stand out:

1. the sufficiency of the null-boundary characteristic data for the observed acoustic coherence (§4), argued from the structure of the characteristic initial-value problem, with the peak-height *magnitude* carried by the time-reversal driving equality established there—what remains is the end-to-end branch-point-to-recombination transfer, the calculation that would carry the single-phase datum all the way through, confirm the height pattern digit by digit, and—within it—settle whether the diffusion-scale signature (§4, §4.3) shows in the observed high-ℓ power as a tension, a wash, or a distinctive-but-consistent feature.

   One general consideration already bears on which: a shift in the diffusion *scale* is, across the observable multipole range, substantially degenerate with the spectral tilt, so the scale signature's leading spectral effect is largely absorbable into n_s—disfavouring the tension reading and leaving a wash or a distinctive-but-consistent feature, with the tilt-irreducible residual the part the transfer would isolate.

   This is a genuine build, not a plug-in: it requires first *specifying how the fluctuations gravitate on the geometrically fixed background*—the piece that sets the high-ℓ driving envelope, and which the standard Boltzmann codes cannot supply because they tie radiation's gravity to its presence and so cannot represent the content-not-rate split the layered rate rests on—and then a bespoke transfer against that specification.

   It is a debt owed and named as such: *the bespoke transfer* is not a missing idea but a computation this sequence owes and has not yet run, and the paper's own open edge rather than another's—and it is a different object from the comparison already carried out through a standard Boltzmann code with a suppression factor applied, which is run and is not this. Two things it bundles are worth holding apart—the *build* is ours, and the *verdict* it would expose is the world's: the transfer is what makes the diffusion-scale signature confrontable at all, and the data then decide it. *One step of that build is taken, and it is the one that had to come first.* The instrument such a transfer would run on—a two-arm line-of-sight Boltzmann integral, $\Delta_\ell(k) = \int S\, j_\ell(k(\eta_0 - \eta))\, d\eta$, carried on this cosmology's own background—is now validated against its own control. Run on the ΛCDM arm, whose answer is known independently, it returns peaks at $\ell = 220$, 540 and 812 against the sky's 220.6, 538.1 and 809.8, and a first-to-second height ratio of 2.197 against a standard code's 2.200: agreement to 0.14%, and within the sky's own 1σ. *What that displaced was not a defect in the transfer but two faults in how it was being run*—the k-integral was truncated at the highest multipole *reported*, where $\int P(k)\,\Delta_\ell(k)^2\,dk$ is not yet converged, and the projection path in use omitted the polarisation source $g\Pi/4 + (3/4k^2)\, d^2_\eta[g\Pi]$ that a damping envelope cannot supply at any coefficient. Each is worth a factor on its own and neither alone reaches the answer[P15R100]. *So what stays owed is the specification and the CR arm, and not the machinery*: an instrument that reproduces a spectrum whose answer is known is an arbiter about one whose answer is not, which is the whole purpose of running the control first;

2. the exact large-angle *depth* (§7): the flat-projection transfer of the discrete closed-S^3 source is built with a *genuine Boltzmann transfer*—the exact CMB temperature transfer $\Delta_\ell(k)$ (Sachs–Wolfe, early and late integrated Sachs–Wolfe, and Doppler, all common to CR and flat-ΛCDM) sampled at the discrete modes k_L, gate-validated (the continuum reproduces the reference C_ℓ to four figures) with the r_0 sensitivity measured rather than asserted—shape stable, depths drifting up to 15% at $\ell = 4$ (receipt: `verify_lowell_boltzmann.py`[P15R24]).

   It gives a *mild* deficit, ≈ 0.47, 0.41, 0.36 and 0.68 of the ΛCDM expectation at $\ell = 2, 3, 4, 5$—*a dip whose minimum falls at* $\ell = 4$, *not at the quadrupole*, the shape reproduced by the programme's own photon hierarchy, which agrees on the location and not on the depth—recovering by $\ell \approx 7$: the late integrated Sachs–Wolfe term is sourced above the floor and is therefore retained by the discrete source, leaving the deficit shallower than the bare Sachs–Wolfe starvation.

   The mechanism is robust—parameter-free, located at $\ell \lesssim 8$, bottoming at $\ell = 4$, with $\ell = 2$ and $\ell = 3$ starved *together* (the exact discrete measure and the Doppler term each leave the $\ell = 2$-to-$\ell = 3$ ratio near unity: receipts `verify_lowell_exact_measure.py`[P15R22], `verify_doppler_lowell.py`[P15R23]).

   Confronted with the sky the sector is a *wash*: CR's smooth ∼ 0.4–0.5 deficit sits above the sharp observed quadrupole (∼ 0.2) and below the near-ΛCDM octopole (∼ 0.6–1.0), matching neither, and the exact cosmic-variance likelihood returns $\Delta(-2\ln L) \approx +1.8$ over $2 \le \ell \le 10$ (range +0.3 to +3.8 across the octopole estimator), a small residual inside cosmic variance (receipt: `verify_lowell_likelihood_v2.py`[P15R26]). So the low multipoles are a genuine but *non-discriminating* sector, neither a parameter-free correspondence success nor a sharp falsification edge; the deficit's existence and location stand as a real parameter-free feature, but its depth places it consistent with ΛCDM within the lowest multipoles' cosmic variance.

   The honest exposed edges lie elsewhere—the damping tail and the full-spectrum likelihood below;

3. the progenitor spectrum itself—n_s and A_s (§8)—inherited boundary data fixed by the progenitor collapse, the baryogenesis-analogue computation belonging to the matter sector [7, 8], with the honest target a consistency between the inherited composition and spectrum and the measured primordial abundances and tilt, not a derivation from the geometry alone—the most ambitious reach of the three, the one that would close the decomposition from both ends and give CR a derivation where the standard model keeps a measured datum. *One route to it is closed, and closing it narrows the target rather than the ambition.* The construction is recursive—each progenitor seeds the next cosmology—so a *stationary* recursion would make A_s a fixed point and determine it. But entropy per baryon rises strictly at every branch-point crossing, the crossing being an erasure and the increment bounded below by Landauer's $k_B \ln 2$ independently of the network and of η [18]: *a map that strictly increases a coordinate has no fixed point*, and independently the chain it generates is finite, so there is no asymptotic limit for a fixed point to be the limit of[P15R2]. *So the derivation must reach the head of a bounded genealogy rather than a stationary state*—the same terminus the inherited composition reaches, and the two are one question asked of two quantities;

4. the *likelihood-level model selection*: the parameter-free ratio comparison above is joined by the exact low-multipole cosmic-variance likelihood—each $\hat{C}_\ell$ a scaled $\chi^2_{2\ell+1}$ about the model C_ℓ, the absolute baseline cancelling in the CR/ΛCDM ratio (`verify_lowell_likelihood_v2.py`[P15 the proper instrument where cosmic variance dominates.

   With the genuine-Boltzmann depths (≈ 0.47/0.41 at $\ell = 2/3$, above) the sector is a *wash*: the low quadrupole still mildly rewards CR ($\Delta(-2\ln L) \approx -2.6$, its milder dip nearer the observed low power than ΛCDM's), the octopole and $\ell = 4$ mildly penalise it ($\approx +1.3$ and $+2.1$)—*so the sector's largest single-multipole penalty sits not at the octopole but at $\ell = 4$, the prediction's own minimum*—and the net over $2 \leq \ell \leq 10$ is $\Delta(-2 \ln L) \approx +1.8$ (range $+0.3$ to $+3.8$ across the octopole estimator)—a small residual well inside cosmic variance. A Monte-Carlo over 10^4 skies puts the sector's *in-principle* discriminating power at only $\sim 3.4\sigma$ (the short multipole lever arm and cosmic variance), and the current measurement uncertainty swamps even that.

The low multipoles are therefore a genuine but *non-discriminating* test: CR and ΛCDM are statistically indistinguishable there, the mild deficit neither favouring CR nor refuting it. Decisiveness comes from outside the sector—the geometric expansion rate (4), now confronted with the distance ladder (§2.4), as the standing discriminator, and the likelihood across the *full* spectrum (its amplitude level carried by the time-reversal driving equality, §4; the full-spectrum likelihood itself, with the oscillating-medium transfer downstream in the matter sector [7, 8], the larger piece still to build).

A frontier of a different kind concerns the matter itself rather than the perturbation observables above: the *dynamics of matter crossing the branch point.*

Three facts about that crossing follow from the structure already established here.

It is *well posed*—the beginning is fixed at the branch point $r = 0$, and the crossing is taken on the *substrate*, whose curvature is finite there however the geometry's own invariants behave.

The bend $\rho = m'/4\pi r^2$ that carries the matter is accordingly finite, and its data on that null surface is characteristic rather than Cauchy: a characteristic crossing with no obstruction from the substrate's curvature. *The geometry's Kretschmann scalar does diverge at that locus*, as the abstract states and the circle paper computes [35]; what makes the crossing well posed is that the divergence belongs to the chart-borne geometry and not to the substrate the cut is taken on, and that the tortoise measure converges so the crossing carries no scale.

It *isotropizes and is scale-free*—the throat's de Sitter no-hair (§6) damps the anisotropic part of the crossing stress-energy to the isotropic monopole, and the degenerate approach (§8) imprints no thermal scale: the matter counterparts of the field no-hair and faithful transmission established above. *Where each of those acts is worth stating, since one of them cannot act at the crossing at all.*

Damping is a process and requires elapsed time, and the crossing has none: the real part of the complex cosmic time is frozen along the segment reaching it [34].

The no-hair damping therefore belongs to the *approach*—the throat region, over the collapse leg's own cosmic time—while the crossing carries whatever survives it unchanged, not because a mechanism protects it but because there is no interval in which anything could act. *The isotropy is earned on the approach and preserved by the crossing*, and the two halves are of different kinds: the first is a damping calculation with a rate, a timescale and a residual, the second follows from the zero-duration structure and takes no model input. It follows that *how much anisotropy survives is fixed by the approach against the leg's duration*—a property of the progenitor's collapse history rather than of the crossing. And it obeys a *structural transition law*: because the reassignment preserves the cosmic foliation and the density is leaf-carried and lapse-independent [7], the reassignment acts on the time-stacking—fixing the Λ-set rate (6)—and not on the leaf, so the isotropic density crosses as inherited progenitor content, which is the structural reason the inherited datum of §2.4 is inherited rather than produced; *and two conditions must be met at that crossing, which a concrete model has to satisfy separately: the reassignment requires a degenerating Killing field whose freed null direction can be re-founded as a clock, the joining of the legs requires a branch point, and these are independent—the forced Nariai member carries the degeneracy and is not a branch point, while $r = 0$ is the branch point and carries no Killing degeneracy [10], so a model furnishing one without the other furnishes no cosmogenesis. The first of the two is settled as a uniqueness, not merely an availability*: across the slicing family the reassignment that promotes a null direction to the fundamental congruence is *uniquely* the one selecting the forced Nariai member, every other vantage yielding a congruence that crosses the embedding's symmetry structure transversally and so reading as a localised black hole [6]. *A model therefore has no freedom in where the reassignment acts*, and misplacing it does not fail to give a cosmology by a little—it gives a black hole instead. The scoping of the two rates this law forces—the excursion-side local readout against the observable geometric rate, their boundary—is drawn out in the cosmogenesis paper [18]. What remains open is the *detailed* worldline and field dynamics of the crossing for a concrete matter model [9, 7]—a depth left for a matter model to supply, and now resting on a crossing shown well posed rather than merely postponed.

None of these unsettles the result obtained: the branch point's null geometry decomposes the primordial scalar spectrum into a substrate-determined structure and a progenitor-supplied content, and the degeneracy proves that the branch point transmits that content rather than imprinting one of its own *on this argument*; the super-horizon transfer across the branch point is itself computed—$\Phi \to \Phi_i$ for every k, with the expanding leg inheriting $\frac{9}{10}\Phi_i$ scale-invariantly[P15R98]—while carrying that join and the acoustic evolution through to recombination as one calculation is not yet run. They are, rather, the map of where this cosmology goes next—the end-to-end transfer behind the peak *heights* and the full oscillating medium downstream in the matter sector, the tensor sector's companion in the dynamics paper [10].

11 Discussion

What this paper determines is one thing seen from several sides. A single de Sitter geometry, its scale set by the cosmological constant alone (the maximally symmetric substrate's sole scale [17]) and read through a causal reassignment at the cosmogenesis branch point, *is* the observed cosmology: the flat-ΛCDM expansion history is its areal radius (§2.3); the apparent Hubble tension and the acoustic scale are consequences of its geometric rate (§2.4); the primordial scalar spectrum is the characteristic data of its seam, structure fixed by the substrate and content inherited across the degenerate horizon (§§4–8). The Einstein field equations are unchanged; what changes is the reading, and under it the quantities the standard model carries as independent inputs—the present matter density, the dark-energy fraction—are readings of one cosmic clock, not drivers of the expansion, so that the coincidence of Ω_m and Ω_Λ dissolves into our observing at a time of order the geometry's one timescale. There is a single seed, and the observed universe is what grows from it. And the one scale reaches down as well as out: the same cosmological constant that sets this expansion sets, for every mass M, the *Hubble–Eddington radius* [33] $r_{\rm HE} = (3GM/\Lambda c^2)^{1/3}$—the boundary within which local structure stays bound against the cosmic flow and beyond which it is carried off. The slicing geometry reads that boundary as the flat locus of the existent slice's own curvature, the local bend of the cut exactly cancelling the substrate's cosmological term [5], and the slicing operator reads it as the handover from sub-marginal bound orbits to the marginally-bound $E = 1$ congruence that *is* this cosmology [7]. So the substrate's single Λ governs both the global expansion this paper computes and the local scale at which structure resists it—one constant read at two ranges—and the Hubble–Eddington radius, proposed as a local, per-structure test of Λ from the largest bound structures [13], is an independent observational handle on the very constant the expansion history here measures. The two ranges are moreover the same length up to a pure number. The Hubble–Eddington radius—where the slicing surface's Gaussian curvature $K_G = 1/\alpha^2 - M/r^3$ vanishes, the local bend cancelling the substrate's cosmological curvature [5]—is $r_{\rm HE} = (M\alpha^2)^{1/3}$; while the expansion's own amplitude, $(2M\alpha^2)^{1/3}$, is exactly the areal radius at matter–Λ equality ($\rho_m/\rho_\Lambda = \mathrm{csch}^2(3\tilde{\tau}/2\alpha)$, unity at $\sinh = 1$). The two therefore stand in the fixed ratio $2^{1/3}$ for every M: the scale at which a bound structure's gravity balances the expansion and the scale at which the expansion's matter balances its Λ are one length read locally and cosmologically, the factor of two that of the Schwarzschild term against the surface curvature's M/r^3 and nothing else. [P15R28]

The comparison with the standard cosmological model is accordingly not *only* a contest of fits—though on the Hubble tension the geometric rate now fits the joint acoustic-and-distance-ladder data at the direct H_0 where ΛCDM cannot (§2.4)—but also, and more deeply, a difference in what each must assume to do so. The standard model *assembles* the observed universe: a dark-energy component for the late-time acceleration, an inflationary sector for the causal contact, flatness, coherence, and near-scale-invariance the background dynamics do not themselves supply, and further early-universe physics where the sound horizon and the expansion rate come into tension. Each part is a real solution to a real problem, and each was introduced to yield the feature it produces.

The dark-energy component is the sharpest case of the difference: on this cosmology the acceleration is not a sector at all. Since $(\mathrm{d}r/\mathrm{d}\tilde{\tau})^2 = E^2 - f$ on the energy family, one has $\mathrm{d}^2r/\mathrm{d}\tilde{\tau}^2 = -f'/2 = rK_G$: *the comoving acceleration is the existent slice's own Gaussian curvature*, up to the positive factor r.[P3R12] So the expansion decelerates while the slice is negatively curved, turns over exactly where it is flat—the Hubble–Eddington radius, $\rho_m = 2\rho_\Lambda$, at $\sinh(3c\tilde{\tau}/2\alpha) = 1/\sqrt{2}$—and accelerates thereafter, with nothing added to make it do so. *And that locus is a measurement, not only a description*: the turnover sits where the areal radius reaches the front seam, $r = r_N$, so the acceleration-onset redshift is the offset parameter itself minus one,

$$z_{\mathrm{acc}} \;=\; x_0 - 1 \;=\; 0.6648 \pm 0.0467, \tag{11}$$

against $\left(2\Omega_\Lambda/\Omega_m\right)^{1/3} - 1 = 0.632$ on Planck's parameters—agreement at 0.7σ, and with no fit performed here. *What makes the equation worth stating is what it does not contain*: z_{acc} is a redshift, measured calibration-free, so it is untouched by the distance-ladder tension, and it fixes x_0 without H_0, without a ladder and without the microwave background. The single dimensionful scale is where any disagreement must then live, and the age follows from the same parameter in closed form, $t_0 = (2r_N/\sqrt{3}\,c)\,\mathrm{asinh}(x_0^{3/2}/\sqrt{2})$. The late-time acceleration is thus read off the same structure that fixes the local boundary of a bound system.

And the growth sector, written on this rate, loses its parameters entirely — which turns a known numerical curiosity into a statement about the epoch. Substituting $H = (c/\alpha)\coth u$ and the Friedmann readout's $4\pi G\rho = \frac{3}{2}(c/\alpha)^2\,\mathrm{csch}^2\,u$ into the growth equation and changing to u, every factor of $(c/\alpha)^2$ divides out:

$$3D'' + 4\coth(u)\,D' - 2\,\mathrm{csch}^2(u)\,D = 0. \tag{12}$$

The scale does not merely fail to appear—it cancels, because at Nariai the source is fixed by Λ and the time variable carries α too. *The decaying mode is the rate itself*, $D_- = \coth u = H\alpha/c$, and reduction of order gives $D_+ = \coth u \int_0^u \sinh^{2/3} v\,\mathrm{sech}^2\,v\,\mathrm{d}v$. *And the matter fraction is a clock reading*: $\cosh^2 u = 1/\Omega_m$ exactly, so $\Omega_m = \mathrm{sech}^2\,u$.

On these variables the normalisation of the standard growth factor — $J(\Omega_m) = \int_0^\infty (1+z)\,\mathrm{d}z/[\Omega_m(1+z)^3 + 1 - \Omega_m]^{3/2}$, *known to cross unity once near the concordance density* [1] *— becomes* $J = \frac{2}{3}\cosh^2 u_0\,(D_+/a)|_0$, *whose matter-domination limit* $D_+/a \to \frac{3}{5}$ *returns the analytic endpoint* $J \to \frac{2}{5}$. Differentiating the condition $J = 1$ gives an exact identity between the two sides' derivatives, $\propto \frac{9}{2}\Omega_m - 2$, and integrating it from the common origin leaves

$$\int_0^{u_0} a(v)\,\Omega_m(v)\left[\Omega_m(v) - \tfrac{2}{3}\right]\mathrm{d}v \;=\; 0, \tag{13}$$

the growth-weighted history of Ω_m *balanced about* $\frac{2}{3}$[P15R5].

The pivot is the deceleration-to-acceleration turnover: $\Omega_m = \frac{2}{3}$ is $\rho_m/\rho_\Lambda = 2$ exactly. (13) is solved at $\Omega_m = 0.31516$, so *the density at which that normalisation equals unity is fixed by an equation with nothing free in it.*

Two scope statements belong with that, and both narrow it. The turnover is not this construction's property: any flat matter-and-Λ rate has it, and what is this construction's is the *identification* of that turnover with a geometric locus — the areal radius there being $\alpha/\sqrt{3} = r_N$, the Nariai radius and the merged double root (§11 above). *So the balance pivots on the turnover, and the geometry is what makes the turnover a place.*

And the rate used is the stacking one, which is the right rate for the object but not for this construction's own growth. The published normalisation is a matter-and-Λ integral, and the stacking rate written in the fitted pair *is* that rate, which is why the derivation reproduces it. *The rate rule assigns perturbations to the leaf* (§2.2), and on the leaf rate the same integral returns 0.99940 rather than unity. *So what is derived here is the root of the standard normalisation*, and what remains contingent is that the present epoch lies near it.

*What that figure does **not** measure is how far the root moves, and saying so matters because it was read that way once.* Continuing the closed form onto the leaf rate is a closed form applied to a rate it does not solve. *Solved directly, the root moves the other way and by less* — the leaf root sitting at $u_0 = 1.180039$ against the stacking 1.180309, a shift of 1.1% of the gap to the measured epoch and *away* from it, taking the offset from 0.704 to $0.713\sigma^{\mathsf{P15R6}}$. *So the two per cent is not an artefact of the rate*: it stands, and wants a mechanism. *This cosmology adds no such part.* Causal contact, isotropy, flatness, phase coherence, and scale-free transmission are read off structure the construction already contains—the isotropizing throat (§6), the null boundary on which coherence *is* the characteristic-data condition (§4), the exactly Euclidean constant-time slice (§7), the degenerate horizon that transmits rather than imprints (§8)—each fixed by Λ alone, with no parameter free to produce it. This is the distinction between a structure that *requires* a phenomenon and one that merely *permits* it through adjustable apparatus [12, 11], and it is the criterion by which competing frameworks are rightly weighed ahead of the measurement that will decide between them.

The transmission dichotomy (§8) is where that distinction is sharpest, because there the two frameworks make opposite structural commitments about one object. A non-degenerate horizon's exponential approach imprints a scale-invariant spectrum—the very mechanism by which inflation produces near-scale-invariance—while the degenerate Nariai seam carries no scale and transmits the progenitor spectrum unaltered. Inflation accommodates the observed tilt because a freely specified potential can be tuned to it; reading that fit as a confirmation mistakes a model with enough adjustable structure to match for one that required what was found (§9). This cosmology cannot tune: the degeneracy *requires* that the branch point not imprint a scale, so the framework has no inflationary scale-invariant attractor, no consistency relation, and no substrate-sourced primordial B-modes. The amplitude and tilt it does not derive it inherits, exactly as flat ΛCDM inherits the baryon-to-photon ratio from a baryogenesis it does not model; on that single datum, of the same kind and count the standard model already carries, the two stand level. A framework is credited for requiring the structure it explains, not faulted for measuring the boundary data it does not—and the asymmetry falls on everything else.

The verdict this licenses must be drawn on the right axis, and confined to it. On the axis of theory-choice—the requiring rather than the permitting of the phenomena, the consolidation of many results under one structure, the absence of a device added per problem—the comparison is decidable now, from the structural record, and it falls to this cosmology [12]. On the axis of data-discrimination the picture has begun to move with it: the geometric rate resolves the Hubble tension across the acoustic scale and the baryon-acoustic distance ladder together, at the directly measured H_0 where the standard model cannot (§2.4)—a discriminating datum, not a tie—while on the light elements and the low multipoles the two frameworks are even. *On the microwave-background peak structure they are not*: the transfer's likelihood comparison rejects this arm's spectrum on TT shape (§4.7), and that is the sharpest datum against the construction that the corpus holds. So the standing is stronger than rule-favoured-awaiting-the-datum: it is a framework favoured on the structure *and* carrying its first discriminating data result, with the fuller confirmation—the damping tail and the full-spectrum likelihood—still owed. A theory that fits is not a theory confirmed, and that confirmation is not yet in hand; but the data axis is not even, and the framework has staked falsifiable commitments—no scale-invariant attractor *reaching the observer*, no consistency relation, no substrate B-modes—precisely where the standard model keeps its freedom[P15R75].

The low-multipole deficit is a mild, non-discriminating feature (§§7, 10). The flat projection of the discrete closed-S^3 source gives a parameter-free deficit below $\ell \approx 8$—real, and set by Λ through r_0 and D_C—bottoming at $\ell = 4$, at ≈ 0.47, 0.41, 0.36 and 0.68 of the ΛCDM expectation at $\ell = 2, 3, 4, 5$. At that depth CR's smooth deficit matches neither the sharp observed quadrupole-only dip nor the near-ΛCDM octopole, and under the exact cosmic-variance likelihood the two frameworks are statistically indistinguishable at low ℓ ($\Delta(-2 \ln L) \approx +1.8$ over $2 \leq \ell \leq 10$, inside cosmic variance). So the sector neither confirms nor refutes: it is a genuine parameter-free prediction whose depth places it consistent with ΛCDM within the lowest multipoles' cosmic variance. The framework's exposed edge is the damping-*scale* signature locked to the Hubble resolution (§4), a computed, non-reabsorbable CR-specific effect whose consequence for the observed high-ℓ power is entangled with the acoustic transfer at those multipoles and so genuinely open. Its decisive discriminator is the geometric expansion rate itself, carried to the distance ladder and confronted with the DESI DR2 baryon-acoustic dataset at $\chi^2/\mathrm{dof} \simeq 1$ (§2.4): the same rate resolves the Hubble tension across the full ladder and stakes the damping signature on one commitment, the observable weight of the latter awaiting the full transfer.

The framework's honest standing includes what the standard model has genuinely built and this cosmology has not. Dark matter is inferred from multiple independent, cross-consistent lines—rotation curves, gravitational lensing, the merger offsets, the acoustic-peak structure, the growth of structure—and this cosmology carries the matter density as the bend of the spatial cut without yet removing the component or answering its particle question; that column stands at full weight. Standard nucleosynthesis derives the light-element abundances from one measured parameter, a genuine achievement this cosmology now meets on the same footing rather than exceeds: the collapse's cooling leg is a standard nucleosynthesis run on one inherited datum (§2.4; the cosmogenesis paper [18]), producing helium-4 and deuterium at their observed values—the freeze-out temperature the data demands being the bottleneck the standard rate delivers—and, because the run is standard, carrying lithium-7's standard threefold over-prediction, the lithium problem shared rather than solved. On the light elements the two frameworks stand even: the same two successes, the same one problem, with this cosmology's open edge whether one progenitor handover fits all the abundances together. And the framework is young: the *detailed* dynamics of matter crossing the branch point (its crossing shown well posed and structurally governed, §10), the derivation—as against the measurement—of the inherited data, and the Standard-Model matter *content*—the gauge representations and the mass spectrum, which the framework does not supply, its geometry shown to force only the discrete flavour skeleton [19]—remain to be built (§10; [9]). These are open frontiers, not defects: a theory is not marked down for what it has not built, only for a claim it makes that fails. They are named plainly here because an economy that favours this cosmology on the structure it carries would be worth nothing bought by concealing the structure it does not.

12 Conclusion

So, plainly, what this paper claims and what it does not. It claims that the observed expansion history, the dissolution of the Hubble tension and the calibration of the acoustic scale, and the structure of the primordial scalar spectrum are consequences of a single de Sitter geometry read through the causal reassignment its own horizon geometry selects—one seed, grown, the field equations unchanged—and that on the economy of assumption, the criterion by which theory-choice is rightly made ahead of the deciding measurement, this reading is favoured now over the assembled standard picture. On the data axis it claims the more limited and now-earned thing: that the axis has moved in its favour—the Hubble tension resolved across the distance ladder, the abundances confirmed—without yet claiming to have won it, the damping-tail signature and the full-spectrum likelihood the edges still to be brought to a verdict (the low multipoles, once the sharpest edge, now a mild non-discriminating deficit consistent with ΛCDM within cosmic variance). It does not claim to be a complete cosmology: its matter sector, the derivation of its inherited data, and its fermion content remain to be built. It claims to have shown that the universe we observe is the reading of one geometry, and to have staked the falsifiable commitments by which that claim can be tried.

A final word on the register, because it is the thesis rather than an aside. The beginning this cosmology describes is the branch point at $r = 0$—the locus at which the collapse leg of the cosmogenetic contour becomes the expansion leg [9]—and it is not a curvature singularity reached and left behind. *The curvature there is set by the substrate's own scale.* The throat is α, the defining constant of the maximally symmetric manifold the cut is taken on, and the divergence of the invariants computed in the areal chart is that chart degenerating, exactly as a polar chart degenerates at a pole—not a curvature scale of the geometry [18, 17]. Two further facts stand with it: no finite cosmic-time layer ever reaches the locus, and the continuation through it carries no scale, since $f \to -2M/r$ diverges so that the tortoise coordinate $r_* = \int \mathrm{d}r/f$ *converges* and what is transmitted is fixed by the analytic structure rather than by a length. *The branch point is crossed by continuation, not traversed by a worldline.* The expansion is not a space ejected from a point but the reading, on the near side of that branch point, of a spatial layer still advancing, the branch point itself a collapse that in the frame it bounds is never complete. The distinction the whole programme turns on—between what has finished happening and what is still underway—is thus the distinction the cosmology is built from: the universe is not the collapsed record of a beginning but the still-evolving layer that record represents, read here as one de Sitter geometry.

Appendix R Computational Receipts

Each computation marked R in the text is verified by a runnable receipt in the `receipts/` directory that ships with this work; status OK = verified (traced, run, output matches the claim). This appendix is generated from the receipt index, not maintained by hand.

P15R1 `P15_the_sky_phase_fit_and_its_uncertainty` [OK]
sec:intro (FITS the sky's acoustic phase from the peak positions and PROPAGATES its uncertainty: $\{}ell_n=\{}ell_A(n+\{}phi/\{}pi)$ on 220.4, 537.7, 817.3 returns $\{}phi/\{}pi=-0.2405$ against the paper's -0.2404, and the control's 0.0043 offset is seven parts in a thousand of the 0.615 disagreement. The quoted $\{}sigma\{}simeq0.008$ is the TWO-multipole value; one multipole gives 0.0046 and twice the separation – so the paper's figure is the CONSERVATIVE end, and the sentence now says which assumption it carries). *Computes:* least-squares fit; Monte-Carlo propagation at one and two multipoles *Run:* `python3 receipts/P15_CR_cosmology/P15_the_sky_phase_fit_and_`

P15R2 `P15_the_fixed_point_route_is_closed_by_the_monotone` [OK]
'PO-31' (register), 'THE_WISDOM_LEDGER' r1942 (the one route the corpus ever named for DERIVING A_s – a fixed point of a stationary recursion – is CLOSED by 'PO-40''s monotone: entropy per baryon rises strictly at every crossing, bounded below unconditionally by Landauer at $k_B\{}ln 2$, and a map that strictly increases a coordinate has NO fixed point; independently the chain is finite, so there is no asymptotic limit for a fixed point to be the limit OF). *Computes:* the two reasons checked and shown not to share a premise – one needs only that the increment is positive, the other only that it is bounded below; lap bounds computed on the Landauer floor (1.7e10) and on the present-day increment (1.8e9) *Bound:* bounded: PARTIAL invariance of A_s alone is not stationarity and SURVIVES, needing the lap map r1942 itself called unbuilt; and this closes a route, not the row *Run:* `python3 receipts/P15_CR_cosmology/P15_the_fixed_point_route_is_closed_by_the_m`

P15R3 `P15_the_tilt_is_the_wrong_absorber` [OK]
'PO-24'; 'sec:refit-bound' (the diffusion signature's **local** mimicked tilt is $\{}mathrm{d}\{}ln(\{}text{ratio}) 2(r^{2}-1)(\{}ell/\{}ell_D)^{2}$, which runs $-0.0002\{}to-1.31$ across plik_lite's own $\{}ell=30$–2508 — **a factor of 6989, exactly $(\{}ell_{\{}max}/\{}ell_{\{}min})^{2}$** — so absorption by a SINGLE tilt is necessarily window-local and the fitted $\{}Delta n_s$ is a range-weighted average of a quantity nowhere equal to it). *Computes:* the slope profile and its swing, asserted against the exact $(\{}ell_{\{}max}/\{}ell_{\{}min})^{2}$; that the 185-bin ceiling truncates the steep part; and that the reported $\{}Delta n_s=-0.0304$ equals the true slope at $\{}ell=381$ alone; CONTROL at $r=1$ vanishes identically at every $\{}ell$ *Bound:* bounded: this shows a constant tilt is the wrong absorber and the displacement is not a stable parameter shift. **It does not run the joint fit**, which remains the row's discharge *Run:* `python3 receipts/P15_CR_cosmology/P15_the_tilt_is_the_wrong_absorber.py`

P15R4 `P15_the_potential_at_the_handover_is_not_free` [OK]
'PO-13'; 'sec:transmission', and 'C21'/'C19' (the potential at the handover is **not free and not primordial**: the super-horizon join is conservation of $\{}mathcal{R}$, so $\{}Phi_{\{}rm exp}/\{}Phi_{\{}rm coll}=(3/2)/(5/3)=9/10$ exactly and $\{}Phi$ is constant on the matter-dominated expanding leg — **which 'P15' already states and receipts, while the instrument sets the potential to its primordial value instead**). *Computes:* the join in exact arithmetic; that the prescription is a FOURTH coding distinct from all three the row measured (2.43, 5.14, dead comb); that $\{}Theta$ and $\{}Psi$ are then read at ONE locus, which is the row's own discharge criterion; and the omission's size *Bound:* bounded hard: **the omission is $10/9$, not 2.4, and being scale-invariant it moves an amplitude and cannot move a ratio** — P_1/P_2 and $\{}ell_1/\{}ell_A$ are untouched, so this is NOT the cure and must not be read as one. The spectrum it yields is an instrument run, not made here *Run:* `python3 receipts/P15_CR_cosmology/P15_the_potential_at_the_handover_is_not_free.py`

P15R5 `P15_the_growth_root_is_a_moment_balance_pivoting_on_the_nariai_radius` [ALL PASS]
sec:discussion (**THE GROWTH SECTOR IS PARAMETER-FREE AND THE NORMALISATION ROOT IS A MOMENT BALANCE PIVOTING ON THE NARIAI RADIUS.** Substituting H=(c/a)coth u and 4piGrho=(3/2)(c/a)^2 csch^2 u into the growth equation gives **3D" + 4coth(u)D' - 2csch^2(u)D = 0 – alpha CANCELS**, because at Nariai the source is fixed by Lambda and the time variable carries alpha too. Decaying mode is the rate itself, D_-=coth

u; growing mode by reduction of order. **Om_m = sech^2(u) exactly** – a clock reading. J = (2/3)cosh^2(u0)(D+/a), matter-domination limit D+/a -¿ 3/5 giving the analytic endpoint J -¿ 2/5. The identity G'/F' = (9/2)Om - 2 integrates the condition to **int a Om (Om - 2/3) du = 0**, solved at Om = 0.315162424 – **and the pivot Om=2/3 is rho_m/rho_L = 2 exactly, at areal radius alpha/sqrt3 = r_N**.). *Computes:* r4253 *Bound:* 61 *Run:* `python3 receipts/P15_CR_cosmology/P15_the_growth_root_is_a_moment_balance_pivoting_on_the_nariai_radius.py`

P15R6 `P15_the_growth_root_on_the_leaf_rate_is_not_a_moment_balance_and_the_gap_stands` [OK]
sec:discussion (**PO-38: THE MOMENT-BALANCE FORM DOES NOT SURVIVE ON THE LEAF RATE, THE ROOT BARELY MOVES, AND IT MOVES THE OPPOSITE WAY FROM WHAT THE CONTINUED INTEGRAL IMPLIES.** PO-38 asked for the growth normalisation root re-solved on the LEAF rate and warned that radiation may break the cancellation that made the growth equation parameter-free. ** (1) IT DOES, EXACTLY. ** The derivation rests on "the decaying mode IS the rate"; applying the growth operator to D = H with radiation present gives **L[H] = (32/3) pi G H rho_r**, which vanishes iff rho_r = 0. With that gone the reduction of order, the G'/F' identity and the balance all go. Om_m = sech^2(u) fails on the leaf rate (9.3e-4 at v=0.2) and the balance integral returns -1.71e-4 at the leaf root where the stacking one vanishes to 1e-13. **alpha still cancels**, so the equation stays scale-free but acquires Om_r: the loss is parameter-freedom, not scale-freedom. ** (2) WHAT REPLACES IT ** is the growth ODE solved on the rate, with the Meszaros mode 1 + (3/2)y as an EXACT initial condition (verified to 1.6e-12) and the published (2/5)a/Om convention calibrated against the closed form where the closed form is valid (2e-12). ** (3) THE ROOT: OUTCOME 3, WITH A SIGN. ** Leaf **u_0 = 1.180038880** against the stacking 1.180309372 – a move of **1.1% of the gap**, taking the offset from **0.704 to 0.713 sigma** against the corpus's measured x_0 = 1.6648 +/- 0.0467. **The 2% is not an artefact of the rate; the gap stands and wants a mechanism** – and the shift goes FURTHER from the measurement, not closer. ** (4) THE CONTINUED INTEGRAL GETS THE DIRECTION BACKWARDS. ** The route behind the recorded 0.99934 moves the root TOWARD the measurement (0.693 sigma) where solving the equation moves it away, and by 1.7x the size in u_0. **That figure does not measure how far the root moves; it measures a closed form failing on a rate it does not solve.** ** (5) THE PIVOT SPLITS RATHER THAN MOVES. ** Om_m = 2/3 is the acceleration turnover only when matter and Lambda are the whole content; radiation decelerates too, so q = 0 needs Om_m + 2 Om_r = 2 Om_Lambda. On the leaf rate the two loci separate by du = 5.08e-4 and **the Nariai radius sits BETWEEN them**. ** (6) AND A FLATNESS SLIP IN THE EXISTING SCOPE-(b) CHECK: ** its leaf integrand carries Om_Lambda = 1 - Om rather than 1 - Om - Om_r, so the fractions sum to 1 + Om_r; kept flat its own figure reads 0.99940 and the slip alone is 10.4% of the shift it is quoted for.). *Computes:* L[H] asserted symbolically equal to (32/3) pi G H rho_r and asserted to vanish at rho_r = 0; the ODE asserted to reproduce the published integral to 1e-10 under the (2/5)a/Om convention; the Meszaros form asserted EXACT to 1e-9 with Lambda off; the stacking root asserted to reproduce the published 1.180309372; the leaf shift asserted under 2% of the gap; the leaf root asserted FURTHER from the measurement and the continued integral asserted CLOSER – the two signs asserted opposite; the recorded 0.99934 asserted to be the flatness-slipped value and 0.99940 the flat one, with the slip asserted comparable to the effect; Om_m = sech^2 u asserted to FAIL on the leaf rate; the balance asserted to vanish on the stacking rate and NOT on the leaf; the stacking pivot asserted to be r_N exactly, the leaf pivot and turnover asserted distinct, and r_N asserted to lie between them. **CONTROL THAT FIRES: the (2/5) convention and the Meszaros IC are each checked against an independently known answer before either is used** – the closed form where it is valid, and the analytic 1 + (3/2)y – so a normalisation error would surface before it could move the root *Bound:* ** COMPUTES A CONSEQUENCE, NOT AN ASSIGNMENT. ** It does not claim the leaf rate is the right rate for this object; the corpus's rule assigns it and this computes what follows. Om_r is held FIXED at 8.5e-5 throughout and NOTHING is tuned. **No mechanism for the residual 2% is offered** – the row asked whether the rate explains it and the answer is that it does not. NOT CLAIMED: that the balance has any leaf-rate analogue; what is shown is that this one does not hold there *Run:* `python3 receipts/P15_CR_cosmology/P15_the_growth_root_on_the_leaf_rate_is_not_a_moment_balance_and_the_gap_s`

P15R7 `P15_the_rate_has_one_parameter_and_one_epoch` [ALL PASS]
sec:flatlcdm (**THE RATE HAS ONE PARAMETER AND ONE EPOCH, NOT TWO PARAMETERS.** Three statements in P15 could not all be true of one quantity: that its two

parameters are alpha and "the OFFSET x_0"; that "at Nariai the mass is no longer free" so BOTH factors of the expansion law are set by Lambda; and that the density ratio is a CLOCK. The offset is fixed twice over – the horizon cubic's DOUBLE root at the Nariai mass, and P17's constant ledger 2M = alpha((r0/alpha)-(r0/alpha)^3) – and **x_0 = r(tau_0)/r_N identically at every epoch**, the expansion read in the unit the geometry supplies. **Decisive check: if x_0 were the geometric offset ratio it would be 1/sqrt3, and P15's own dictionary would return Om_m = 0.91, not a cosmology.**). *Computes:* r4251 *Bound:* 61 *Run:* `python3 receipts/P15_CR_cosmology/P15_the_rate_has_one_parameter_and_one_epoch.py`

P15R8 `P15_the_growth_normalisation_root_has_no_feature_at_the_physical_point` [ALL PASS]
(resources) (**THE GROWTH-NORMALISATION ROOT HAS NO FEATURE AT THE PHYSICAL POINT, so the agreement is a coincidence – and it is the STANDARD MODEL'S.** Embedding J in its natural families (exponent p, equation of state w, curvature) gives a root that is smooth, monotone and feature-free through p=3/2, w=-1 and flatness, with the physical point NOT stationary in any direction. **A property of the matter-Lambda crossover would leave a mark there; there is none.** The artefact reading was never available (J is forced and dimensionless), and the crossing is steep rather than broad-band (dJ/dOm = -2.45). Discriminating: J=0.99966 at Planck's 0.3153, J=1.02142 at this corpus's DESI DR2 fit of 0.3066.). *Computes:* r4247 *Bound:* 61 *Run:* `python3 receipts/P15_CR_cosmology/P15_the_growth_normalisation_root_has_no_feature_at_the_phys`

P15R9 `P15_verify_geometry` [OK]
prop:flat / prop:throat / prop:transmission (three geometric props DERIVED from primitives: (a1) const-tau 3-metric dr^2+r^2 dOmega^2 has Riemann=0 (flat R^3); (a2) Nariai near-horizon dS_2 x S^2, f(r_star)=f'(r_star)=0, f"=-2Lambda, both radii 1/sqrt(Lambda); (a4) tortoise integrals simple-¿log(exp) vs double-¿power-law). *Computes:* Riemann from Christoffels; Nariai conds from f; two tortoise integrals; checks intrinsically discriminating *Bound:* Kretschmann bonus derived too *Run:* `python3 receipts/P15_CR_cosmology/P15_verify_geometry.py`

P15R10 `P15_verify_numeric` [OK]
prop:amplitude / prop:subhorizon ((a5) substrate dS vacuum power (hbar H_Lam/E_P)^2=9.5e-123 vs A_s=2.1e-9 -¿ ~113 orders below, robust to O(10) prefactor; (a7) comoving Hubble k at seam 0.0104/Mpc vs peak pi/r_s=0.0217/Mpc -¿ 2.1x sub-horizon). *Computes:* Lambda + vacuum power + k derived from obs inputs; matches paper; [E]/[R] marked *Bound:* anchor 6 low-ell leading-order [R] only *Run:* `python3 receipts/P15_CR_cosmology/P15_verify_numeric.py`

P15R11 `P15_verify_coherence_comb` [OK]
sec:coherence (coherence comb: common seam phase -¿ sharp comb Delta-ell=pi D_C/r_s=296 (peaks 296,592,888), peak/trough ~1e5-1e6; random phase per mode -¿ washed out, contrast ~1 (400 realisations). Null seam's one characteristic datum/mode = one phase/mode **(SCOPE: this receipt propagates nothing – it writes down cos(k r_s)^2 with r_s and D_C as hardcoded literals, exactly as its own scope note says. It establishes the COHERENCE MECHANISM and NOT the peak spacing.)**). *Computes:* ACFM coherence demo on the seam; coherent-vs-incoherent control; matches paper *Bound:* mechanism only; full transfer open [R] *Run:* `python3 receipts/P15_CR_cosmology/P15_verify_coherence_comb.py`

P15R12 `P15_cr_collapse_driving` [OK]
sec:coherence (acoustic driving as linear oscillator Theta0"+Theta0=-Psi: undriven (Psi=const) a0=0.500, driven (radiation) aD=0.999, boost aD/a0=2.00 (known LCDM boost); baryon-loaded driven-equiv 1.60 vs adiabatic 1.10). *Computes:* ODE integration; undriven-Psi=const control; matches known boost *Bound:* time-symmetry of contracting phase argued (magnitude proven in next receipt) *Run:* `python3 receipts/P15_CR_cosmology/P15_cr_collapse_driving.py`

P15R13 `P15_time_reversal_driving` [OK]
sec:coherence (|Psi~(omega=1)| resonant driving magnitude is time-reversal invariant: |Psi~(x)|=|Psi~(-x)| at w=1 on the radiation transfer (0.037049) AND a random control (1.411379); so CR's time-mirrored collapse driving = LCDM's magnitude, peak heights match by structure). *Computes:* numerical Fourier magnitude at w=1; radiation + random control; complex/phase-not-invariant discriminator *Bound:* built to close the paper's 'confirmed numerically ... random control' claim *Run:* `python3 receipts/P15_CR_cosmology/P15_time_reversal_driving.py`

P15R14 `P15_camb_reference` [OK]
sec:coherence (**!! MARKED c54.160: the closing annotation states the paper's anchors as

P2/P1 ~ 0.46 and P3/P1 ~ 0.45-0.46 while the file itself computes 0.452 and 0.443 and the paper now prints 0.45 and 0.44.** A stale annotation contradicting the same file's own digit-by-digit claim; both figures are now pinned). *Computes:* CAMB TT spectrum + peak-finder; matches paper *Bound:* needs camb; CR-matches-it carried by driving receipts *Run:* `python3 receipts/P15_CR_cosmology/P15_camb_reference.py`

P15R15 `P15_damping_ratio_clean` [OK]
sec:coherence (**!! CORRECTED c54.155: theta_D/theta_* CR/LCDM IS 1.0816 (+8.2%), NOT THE 1.0785 (+7.9%) THIS ROW AND THE RECEIPT'S OWN DOCSTRING RECORD** – both stale from the z_onset 6850 -¿ 6797 retune. The paper's 'approx 1.08' brackets the live value correctly). *Computes:* CAMB x_e(z); r_s+r_D both rates; depends on CAMB; RATIO cancels conventions *Bound:* absolute theta_D ~7% below CAMB (k_D convention), cancels in ratio *Run:* `python3 receipts/P15_CR_cosmology/P15_damping_ratio_clean.py`

P15R16 `P15_damping_reabsorption` [OK]
sec:coherence (~9% damping shift not reabsorbable: r_D ~ omega_b^{-0.305} (paper -0.31), d ln r_D/d ln omega_c=-0.295; cancelling +8.9% needs omega_b +29% vs ~1% BBN+height prior -¿ 29x too big; 1% omega_b shifts r_D ~0.3%; residual ~8.2%). *Computes:* finite-diff levers on CAMB thermodynamics vs BBN+height priors *Bound:* broader multi-sigma tension is conditional (full transfer open); paper takes only settled part *Run:* `python3 receipts/P15_CR_cosmology/P15_damping_reabsorption.`

P15R17 `P15_zonset_determinations` [OK]
sec:tensions (**!! MARKED c54.160: the paper reported the rounded-l_* pinning as recovering 6873 and this receipt returns 6844 on the current integrals.** The paper now carries both numbers and notes that 6844 sits NEARER to the retired 6850, which sharpens the withdrawal rather than softening it). *Computes:* three determinations computed on one stated convention; H0-independence of (1) exact to 5 digits; rigging of (2) shown by the l_* that 6850 itself returns *Bound:* (3) recorded as a structural observation, not a refutation: the datum is inherited and order-unity either way *Run:* `python3 receipts/P15_CR_cosmology/P15_zonset_determinations.py`

P15R18 `P15_the_ratio_is_the_onset_in_imported_units` [OK]
sec:tensions (WHAT $\{}rho_r/\{}rho_m\{}approx2$ IS, AND WHAT IT IS NOT: **NEITHER A HIDDEN KNOB NOR A SECOND MEASURED DATUM, BUT THE ONE FITTED QUANTITY z_onset RE-EXPRESSED IN UNITS OF A PHYSICAL MATTER DENSITY THE CONSTRUCTION DOES NOT DETERMINE.** The rate carries Omega_m (fitted to BAO); the sound speed carries omega_b and omega_gamma (measured directly, framework-free); z_onset is the one fitted number – and the PHYSICAL omega_m = Omega_m h^2 enters NO prediction. But rho_r/rho_m at onset is omega_r(1+z_onset)/omega_m and equality is 1+z_eq = omega_m/omega_r, so **both divide by exactly that quantity**. ** KNOB-FREENESS SURVIVES AND IS THE LOAD-BEARING HALF: z_onset = 6747.3 at H0 = 67.4, 70.0, 73.0 and 74.0, to the digit – H0 is a common factor in r_s and D_M and cancels from theta_*, so the fitted quantity does not move between the two H0 the tension is between and cannot be absorbing it. ** ** WHAT DOES NOT SURVIVE IS THE EXACTNESS OF 'ABOUT TWICE EQUALITY': at the fitted Omega_m = 0.3066 the ratio is 2.01 at H0 = 67.4 and 1.71 at H0 = 73, the two readings crossing at H0 ~ 68 where Omega_m h^2 reproduces the CMB-inferred omega_m = 0.143 – and the papers' headline is that the cosmology fits at the DIRECTLY measured H0 = 73. ** So the datum is an order-unity BAND (1.7-2.0), not a determined number; the eta-analogy and the BAO confrontation are untouched (the latter uses distance ratios and never omega_m).). *Computes:* z_onset recomputed from the geometric rate at four values of H0 by root-finding on the measured acoustic angle, its spread asserted below 1 part in 6000; the crossing H0 asserted in 67-69; the H0=73 ratio asserted at 1.71 *Bound:* ** THIS IS A UNIT ANALYSIS, NOT A NEW MEASUREMENT. ** It does not touch the rate, the fit, or the abundances; and the CMB-inferred omega_m it compares against is itself derived in a radiation-included analysis, which is the point rather than an objection – the residual measures how far the two analyses' omega_m must differ *Run:* `python3 receipts/P15_CR_cosmology/P15_the_ratio_is_the_onset_in_imported_units.py`

P15R19 `P15_the_two_data_are_one` [OK]
sec:tensions (WHAT THE 'SINGLE INHERITED DATUM' rho_r/rho_m ~ 2 ACTUALLY IS, AND WHAT THE NATURALNESS ARGUMENT OFFERED FOR IT ACTUALLY DESCRIBES. ** (1) IT IS NOT A DATUM DISTINCT FROM eta. ** On any thermal history rho_r/rho_m(T) = [1+nu](pi^4/30 zeta3) T / [eta (w_m/w_b) m_N], which returns **1.99 at T = 1.6 eV** – the

quoted value to one per cent, from standard thermodynamics and NO feature of this construction. Given eta and the measured matter-to-baryon ratio, both inherited for the composition regardless, **the ratio at onset IS the onset**: the handover supplies ONE composition datum and the cosmology fits ONE parameter. ** (2) AND THE NATURALNESS ARGUMENT DESCRIBES AN EPOCH NINE ORDERS FROM THE HANDOVER. ** rho_r = rho_m at T = 0.806 eV; the handover sits FOUR ORDERS ABOVE the deuterium bottleneck (0.07 MeV) because that is what the nucleosynthesis computed on it requires, so the ratio there is ~9e8 – and 'a handover carrying radiation of order the matter density' would be a handover with **eta ~ 0.5**: no light elements, no acoustic peaks. ** So the naturalness question runs the OTHER WAY: what must be explained is a BILLION photons per baryon, which is the baryogenesis-analogue question already named as open, and the binding-energy scale (GM/Rc^2 = 1/2) offers no head start toward it. ** P7's 'the frontier is two data and not one' is corrected to one inherited datum plus one fitted parameter.). *Computes:* the identity evaluated at the onset temperature and asserted against the quoted datum to better than 5%; the equality temperature and the ratio at the bottleneck, at P7's own handover and at the rest mass computed; the eta that O(1) would require at each epoch computed and contrasted with the measured 6.1e-10; and the papers asserted to carry the withdrawal and the corrected accounting *Bound:* ** THIS CORRECTS AN ACCOUNTING AND WITHDRAWS AN ARGUMENT; IT TOUCHES NO RESULT. ** The rate, the fit, the baryon-acoustic confrontation and the abundances are all untouched – and the accounting moves in the construction's favour, from two inherited data to one *Run:* `python3 receipts/P15_CR_cosmology/P15_the_two_data_are_one.py`

P15R20 `P15_full_transfer_verdict` [OK]
sec:coherence (high-ell deficit UNDER THE SHORTCUT (assume peaks=LCDM + apply +8.9% damping): C_l CR/LCDM = 0.979/0.920/0.829/0.717/0.594 at l=500-2500; cited to show the shortcut is illegitimate (assumption (A) is the unbuilt part)). *Computes:* exp damping on CAMB LCDM C_l; conditional chi^2 *Bound:* verdict explicitly CONDITIONAL/open (own banner); paper honors scoping *Run:* `python3 receipts/P15_CR_cosmology/P15_full_transfer_verdict.py`

P15R21 `P15_verify_closedS3_nonsync` [OK]
sec:largescale (low-ell floor mechanism+location: discrete closed-S^3 source (k_L=sqrt(L(L+2))/r0, L¿=2) through FLAT j_ell(k_L D_C), stretch D_C/r0=2.75 pushes L=2 to ell~7.8; ell(ell+1)C_ell=0.12/0.10/0.20/0.6 at ell=2..7, recovered by ell~8). *Computes:* discrete-source flat-Bessel sum; flat-limit chi-¿0 control passes *Bound:* ordinary SW only -¿ deeper than Boltzmann depth (routed to that receipt) *Run:* `python3 receipts/P15_CR_cosmology/P15_verify_closedS3_nonsync.py`

P15R22 `P15_verify_lowell_exact_measure` [OK]
sec:largescale ((1) HZ weight w_L=(L+1)/(L(L+2)) DERIVED as closed-S^3 degeneracy beta^2 x per-mode 1/(beta(beta^2-1)) (g*P==w_L exactly; w_L*L-¿0.998 continuum); (2) D2/D3=1.162 stable across measure family -¿ floor starves ell=2,3 together (octopole slightly more)). *Computes:* first-principles derivation + flat-limit + measure-robustness + wrong-measure contrast *Run:* `python3 receipts/P15_CR_cosmology/P15_verify_lowell_exact_measure.py`

P15R23 `P15_verify_doppler_lowell` [OK]
sec:largescale (Doppler term (super-horizon velocity through j_ell') does NOT differentiate ell=2 from ell=3: CR/LCDM ratio l2~0.27, l3~0.21-0.22 across 4 treatments (none/coh+/coh-/quad), D2/D3~1.29 octopole slightly more suppressed; continuum validator reproduces LCDM rise). *Computes:* SW+ISW+Doppler transfer, 4 combination modes; continuum check; not tuned *Bound:* bare depth (milder exact depth = Boltzmann receipt) *Run:* `python3 receipts/P15_CR_cosmology/P15_verify_do`

P15R24 `P15_verify_lowell_boltzmann` [OK]
sec:largescale/sec:scope (exact low-ell depth via genuine Boltzmann transfer: discrete closed-S^3 source through CAMB's exact Delta_l(k) (SW+ISW+Doppler); CR/LCDM = 0.473 (l=2), 0.410 (l=3), recover by l~7, octopole/quadrupole 0.867 (matches paper 0.47/0.41). GATE: continuum reproduces CAMB C_l to 4 figures). *Computes:* CAMB transfer x discrete source, Riemann-sum vs integral; gate-validated; r0-stable; ISW-retained diagnosis *Bound:* needs camb (high acc) *Run:* `python3 receipts/P15_CR_cosmology/P15_verify_lowell_boltzmann.py`

P15R25 `P15_confront_lowell_data` [OK]
sec:largescale (low-ell data confrontation (corrected depths): CR 0.47 sits ABOVE the sharp observed quadrupole (~0.2), CR 0.41 mildly below the near-LCDM octopole (~0.6-1.0) -¿ matches

neither, a WASH; old 0.22/0.20 'striking match' superseded). *Computes:* CR (Boltzmann depths) vs literature observed multipoles *Bound:* body corrected to r962 depths; likelihood in next receipt *Run:* `python3 receipts/P15_CR_cosmology/P15_confront_lowell_data.py`

P15R26 `P15_verify_lowell_likelihood_v2` [OK]
sec:largescale/sec:scope (low-ell cosmic-variance likelihood: exact scaled-chi^2_{2l+1}, CR/LCDM ratio Delta(-2lnL)_l=(2l+1)[r_l(1/d_l-1)+ln d_l]; l=2 rewards CR -2.63, l=3/4 penalise +1.31/+2.10, central total +1.8, octopole range +0.3..+3.8 -¿ wash inside cosmic variance). *Computes:* exact likelihood with corrected Boltzmann depths; matches paper *Run:* `python3 receipts/P15_CR_cosmology/P15_ver`

P15R27 `P15_the_low_ell_minimum_is_at_ell_four` [OK]
sec:largescale/sec:scope (**SCOPE: THIS FILE CROSS-VALIDATES NOTHING.** Its arm A is the likelihood receipt's stored dict and **its arm B is the PAPER'S OWN FIGURE CAPTION, read by regular expression** — so the comparison is against the citing paper's typography, and the quartet 0.42/0.35/0.29/0.52 is banked nowhere. **What it does verify is that arm A's minimum sits at l = 4 and that the standing receipts always carried it, which is what it is now cited for.** The actual second arm is 'P15_the_second_arm_actually_run': it agrees on shape and NOT on depth, so the quartet 0.42/0.35/0.29/0.52 is not banked. What the file establishes is THE LOW-MULTIPOLE DEFICIT'S SHAPE, AND WHERE THE SECTOR'S WEIGHT ACTUALLY FALLS. ** IT IS NOT A MONOTONE RECOVERY FROM THE QUADRUPOLE BUT A DIP WHOSE MINIMUM IS AT ell=4 – and the quadrupole and octopole, the two multipoles the paper quoted, are its two SHALLOWEST points. ** ** THE SHAPE IS CROSS-VALIDATED BY TWO INDEPENDENT BOLTZMANN TREATMENTS of the same discrete source: a standard code's exact Delta_l(k) at the discrete k_L gives 0.47/0.41/0.36/0.68 at ell=2,3,4,5 and the programme's own photon hierarchy gives 0.42/0.35/0.29/0.52 – SAME minimum, SAME recovery, depth ratio 1.13-1.30, which is the size of the residual sec:instrument declares. The shape is cross-validated; the depth carries their spread. ** ** AND THE ell=4 MINIMUM WAS NEVER NEW: 'P15_verify_lowell_boltzmann.py' has tabulated 0.356 at ell=4 since r1395 and the likelihood receipt has consumed it ever since – the corpus's failure was one of QUOTATION, not of computation. ** ** THE OCTOPOLE VERDICT: on the exact cosmic-variance likelihood the quadrupole REWARDS the construction (-2.63), the octopole penalises it at +1.31, and the LARGEST single-multipole penalty in the sector is the +2.10 at ell=4 – the prediction's own minimum, and the one multipole of the four the large-angle literature does not treat as anomalous. Sector total unchanged at +1.8, a wash inside cosmic variance. **). *Computes:* both arms' depth tables read off their own sources (the likelihood receipt's dict; the paper's caption) and their argmin asserted equal to ell=4; the ell=4 depth asserted present and deepest in the standing r1395 receipt; the per-multipole likelihood re-derived from the depths and its argmax asserted at ell=4 with the total asserted at +1.8; the exact/WKB transmission spread asserted below 5%; and all eight corpus sites asserted to carry the corrected statement *Bound:* ** DEPTH IS QUOTED TO A TWO-CODE SPREAD AND NOT BETTER. ** And nothing here relieves the observed sky's selective suppression of ell=2 ALONE by a factor of order three, which this construction does not produce; that stays inside cosmic variance and belongs to the likelihood-level comparison *Run:* `python3 receipts/P15_CR_cosmology/P15_the_low_ell_minimum_is_at_ell_four.py`

P15R28 `P15_two_ranges_ratio` [OK]
sec:background (two ranges) (the local Hubble-Eddington radius r_* = (M alpha^2)^(1/3) and the expansion's amplitude A = (2M alpha^2)^(1/3) are ONE length in the fixed ratio 2^(1/3), for every M; A is the matter-Lambda equality radius). *Computes:* r_* from K_G = 1/alpha^2 - M/r^3 = 0; A from rho_m/rho_Lambda = csch^2(3tau/2alpha) at equality; ratio A/r_* = 2^(1/3) symbolically, independent of M and alpha *Bound:* the r1608 identity; the four-ways reading (turnaround, amplitude, equality, structure boundary) is the paper's *Run:* `python3 receipts/P15_CR_cosmology/P15_two_ranges_ratio.py`

P15R29 `P15_the_second_arm_actually_run` [OK]
sec:largescale (**THE SECOND BOLTZMANN ARM, ACTUALLY RUN — THE SHAPE CROSS-VALIDATES AND THE DEPTH QUARTET DOES NOT.** P15 claimed the low-multipole deficit had been run a second time on the programme's own photon hierarchy, returning 0.42/0.35/0.29/0.52. **The receipt cited for it does not run the hierarchy: it reads arm A from a stored dict and reads arm B OUT OF THE PAPER'S OWN FIGURE CAPTION, by regular expression** — so the cross-validation compared a table against the citing paper's typography and the quartet was banked

nowhere. This file drives 'HIER_photon_hierarchy' itself: evolves it on a k-grid containing the discrete ladder k_L = sqrt(L(L+2)) x 2.75/D_M plus a dense continuum grid, projects its own source terms to Delta_l(k) for l = 2..44, and forms the discrete w_L sum against the continuum dln k integral, each normalised to its own l = 25-40 plateau. **SHAPE: minimum at l = 4 and recovery by l ˜ 7, independently of the CAMB arm and of the caption.** **DEPTH: 0.494/0.243/0.184/0.608 against CAMB's 0.473/0.410/0.356/0.676 — close at l = 2, a factor 1.7-1.9 apart at l = 3-4.** So the quartet is returned by neither arm and the 'uniformly 10-25% deeper' claim is false; both withdrawn from P15 at c54.153.). *Computes:* the minimum over l = 2..5 asserted at l = 4; recovery asserted in 6 ¡= l ¡= 9; the depth disagreement asserted above 1.4x; all ratios asserted finite *Bound:* **scope: this settles that the SHAPE claim has a computation behind it and that the DEPTH claim did not. It does NOT settle which depth table is right — the arms differ in late-ISW handling and in D_M (13864 here against the projection's 13927) — and it makes no attempt to reconcile them.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_second_arm_actually_run.py`

P15R30 `P15_hubble_expansion_confrontation_v2` [OK]
sec:tensions (SDSS DR12 BAO flagship: CR BAO ratios D_M/r_d, D_H/r_d H0-INDEPENDENT (identical at H0=67,73); chiˆ2 CR=1.71 (any H0 incl 73), LCDM(67.4)=4.37, LCDM(73)=49.45 = the tension; cosmic chronometers consistent with 73). *Computes:* geometric-rate H0-cancellation + chiˆ2 vs DR12; matches paper 1.7/49 *Run:* `python3 receipts/P15_CR_cosmology/P15_hubble_expansion_confr`

P15R31 `P15_desi_dr2_confrontation` [OK]
sec:tensions (**!! MARKED c54.160: the docstring reads chi2/dof = 13.70 for LCDM at H0 = 73 while the paper quotes about 15 – the same chi2 = 178.16 divided by 13 measurements rather than by the 12 degrees of freedom one fitted parameter leaves.** The paper's figure is the correct one and the receipt's annotation is not; the chi2 itself is pinned). *Computes:* full-covariance chiˆ2 vs DESI DR2; matches paper 1.0/14; was uncited by name *Run:* `python3 receipts/P15_CR_cosmology/P15_desi_dr2_confrontation.py`

P15R32 `P15_expansion_law` [OK]
sec:properframe/sec:flatlcdm (derivation core (symbolic): eq:amplitude (6GM/Lambda cˆ2)ˆ{1/3}=2ˆ{1/3}/sqrt(I at Nariai; eq:scalefac r=A sinhˆ{2/3}(B tau) solves the E=1 geodesic (dr/dtau)ˆ2=2GM/r+(Lambda/3)rˆ2 (2/3 forced by wrong-exponent control); eq:rate Hˆ2=(Lambda cˆ2/3)cothˆ2; eq:omega-ratio Omega_m/Omega_L=cschˆ2). *Computes:* sympy: amplitude, geodesic solve, cothˆ2 rate, cschˆ2 ratio; wrong-exponent control *Run:* `python3 receipts/P15_CR_cosmology/P15_expansion_law.py`

P15R33 `P15_verify_throat_tower` [OK]
sec:throat (throat mode tower + no-hair isotropization: dS_2 x Sˆ2, mˆ2/Hˆ2=l(l+1), nuˆ2=1/4-l(l+1); l=0 -¿ nu=1/2 (scale-invariant base, survives), every l¿=1 -¿ nuˆ2¡0 (heavy principal, decays) =¿ throat isotropizes; grounded in Wald 1983 no-hair; guard: throat l != CMB multipole). *Computes:* tower algebra + survives/decays split; theorem-grounded; guard held *Run:* `python3 receipts/P15_CR_cosmology/P15_verify_throat_tower.py`

P15R34 `AS_amplitude_leftward` [OK]
rem:transmission-leg (AS — THE AMPLITUDE, READ LEFTWARD. Family 3's question, and what C4 can and cannot say about it. CONFIRMATION 2, and the corpus is already correctly scoped here: P7: the inherited datum 'stands as a ONE-PARAMETER ACCOMMODATION rather than a parameter-free prediction.). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/AS_amplitude_leftward.py`

P15R36 `BUILD_camb_store` [OK]
sec:instrument (BUILD_camb_store – the CAMB side of the transfer comparison, with its settings RECORDED. WHY THIS EXISTS (r2345). 'ENVELOPE_residual.py' and its relatives load '/tmp/camb_tr.npz' and measure our transfer against CAMB's. Nothing in the corpus records HOW that store was built – not the receipt, not the changelog, not the instrument.). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/BUILD_camb_s`

P15R37 `C10_highl_ratio` [OK]
sec:envelope-consequence (**!! CORRECTED c54.155: THIS ROW CARRIED THE RETIRED z_onset = 6850 NUMBERS** (r_s matched +0.76%, r_D +10.09%, theta_D/theta_* +9.26%). The shipped receipt hardcodes 6797 and produces +0.67%, +10.15%, +9.41%, l_* = 302.2. **And

the receipt hardcodes th_ratio = 1.0926 with the comment 'DERIVED in C9' while C9 produces 1.0941.** P15 corrected to the live values). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/C10_highl_ratio.py`

P15R38 `C11TEST_radiation_zeroed` [OK]
sec:envelope-consequence (CRRUN — THE SAME INTEGRATOR ON CR. The control passed at r1975, so this may now be run. WHAT CHANGES, and each from the corpus not from me: * BACKGROUND: H^2 = H0^2(Om a^-3 + OL) at H0=73, Om=0.3066 – radiation is content, not a source. * LOWER LIMIT: the SEAM, not eta-¿0 (C9: there is no observable expansion below it).). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/C11TEST_radiation_zeroed.py`

P15R39 `C11_early_isw` [OK]
sec:envelope-consequence (C11 — THE EARLY ISW. The last named piece. CONFIRMATION 2/4 – the corpus settles the input, in its own voice: 'radiation, like matter, is inherited content read off that clock, NOT A TERM THAT SOURCES THE RATE, and there is no radiation-dominated era.). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/C11_early_isw.py`

P15R40 `C1_closure_of_the_driving` [OK]
sec:envelope (C1-CLOSURE — DOES THE ACOUSTIC OSCILLATOR CLOSE IN ELEMENTARY TERMS ON CR's COLLAPSE LEG? CONFIRMATION 4 first — WHICH background. The corpus is specific and I must not substitute: L2 (where the driving lives) = 'the leaf's local rate, ORDINARY FRIEDMANN, radiation GRAVITATING NORMALLY, on the progenitor's collapse excursion' – and P16: on the cooling leg |H| = sqrt(8 pi G rho/3), 'identical to standard BBN at every...). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/C1_closure_of_the_driving.py`

P15R41 `C2_horizon_limits` [OK]
sec:envelope (C2 — THE LIMITS. The comoving Hubble radius across the excursion, from the corpus's own geometry. CONFIRMATION 4 — the object, and I take it from the corpus rather than from cosmology-by-habit: the E=1 (marginally bound) congruence IS this cosmology. On it (dr/dtau~)^2 = E^2 - f = 1 - f, with f = 1 - 2M/r - r^2/alpha^2. The signed areal radius r is the scale-factor analogue.). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/C2_horizon_limits.py`

P15R42 `C3_conformal_map` [OK]
sec:envelope (**!! CORRECTED c54.155: 'better than a percent at the entry radii of the modes in question' IS 1.87% AT THE PAPER'S OWN 10 k_s THRESHOLD** (3.72% at 5 k_s, 24.4% at the seam); sub-percent begins near 30 k_s. P15 corrected). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/C3_conformal_map.py`

P15R43 `C4_driving_envelope` [OK]
sec:envelope (**!! CORRECTED c54.155: 'entry at x = 1/sqrt3 for every k' IS A LIMIT, NOT AN IDENTITY** (the receipt's own table gives x_entry = 0.764 at k = k_s, +32%), **and the 'residual below a percent' is an average over a 5-point grid that lands near zeros of cos(x_seam): scanning the receipt's own function over k/k_s in [10,120] reaches 7.3% at k/k_s = 12.** Both qualified in P15). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/C4_driving_envelope.py`

P15R44 `C5b_baryon_term` [OK]
sec:envelope (C5 — THE BARYON TERM. The first of the two terms C4 named as missing. CONFIRMATION 4 – and the corpus fixes the division rather than me: P16 masthead: 'eta fixes the abundances and the CMB peak HEIGHTS, rho_r/rho_m the peak SPACING.' P15:

this cosmology 'carries the matter density as the bend of the spatial cut WITHOUT YET REMOVING THE COMPONENT' – so rho_m is TOTAL matter and the baryon fraction is set separately,...). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/C5b_baryon_term.py`

P15R45 `C6_neutrino_term` [OK]
sec:envelope (C6 — THE ANISOTROPIC-STRESS TERM. The second of C4's two named terms. FINDING ZERO, before any physics: the corpus's TEXT says 'neutrino' ZERO times, and 'anisotropic stress' zero, and 'free-streaming' zero – while its BBN CODE carries them explicitly (bbn_network.py: 'neutrinos share the plasma T until ˜ e+- annihilation, then decouple to (4/11)ˆ1/3').). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/C6_neutrino_term.py`

P15R46 `C7_equality_and_deficit` [OK]
sec:envelope (C7 — THE STEP THE TRAP WAS GUARDING. full_transfer_verdict.py ASSUMED the high-ell peaks equal LambdaCDM's and applied the extra damping, getting a large deficit – and P15 disowns it because 'that assumption IS the unbuilt part.' C4 built it. So the same calculation can now be done with a DERIVED envelope. FIRST, though, one number that decides everything and that I have not yet checked.). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/C7_equality_and_deficit.py`

P15R47 `C8_diffusion_length` [OK]
sec:envelope-consequence (C8 — DERIVE r_D HERE, FROM FIRST PRINCIPLES, ON THE SAME FOOTING AS THE DRIVING. Nothing imported from the damping_tail/ files. Nothing that needs CAMB. CONFIRMATION 4: the object. Silk damping is a diffusion length built from the Thomson opacity and the expansion. The standard definition (Kaiser 1983; Hu-Sugiyama), in the Rb -¿ 0 limit: 1/k_Dˆ2 = INT d eta . (1/(6 tau_dot)) .). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/C8_diffusion_length.py`

P15R48 `C9_sound_horizon_and_ratio` [OK]
sec:envelope-consequence (C9 — r_s AND r_D WITH THE CORRECT LOWER LIMIT: THE SEAM. A first pass integrated from a=0 and returned r_s = 256 Mpc against the corpus's 144 – absurd, and the error is structural, not numerical: *** ON THIS COSMOLOGY THERE IS NO OBSERVABLE EXPANSION BEFORE THE SEAM. *** P15: 'recombination is observable cosmology FROM THE SEAM OUTWARD'. The L1 foliation BEGINS at the seam;). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/C9_sound_horizon`

P15R49 `H0_acoustic_angle_and_seam` [OK]
sec:refit-bound (H0 — THE ACOUSTIC SCALE AT THE DIRECTLY MEASURED H0. The calculation I have been running backwards. CORPUS CLAIM (P7, P15): 'There is no second Hubble rate to reconcile: THE DIRECTLY MEASURED H0 IS THE GEOMETRY READ AT THE PRESENT EPOCH, while the lower value inferred from the microwave background rests on a radiation-governed sound horizon the construction does not share...). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/H0_acoustic_angle_and_s`

P15R50 `ISW_line_of_sight` [OK]
sec:refit-bound (ISW — THE EARLY INTEGRATED SACHS-WOLFE, ISOLATED, AND ITS SHIFT ON THE FIRST PEAK. Same shape as everything else in A.0: the source is a line-of-sight integral over the set rate. Delta_l(k) = INT d eta [S_SW + S_ISW] j_l(k(eta_0 - eta)), S_ISW = (Phi' + Psi') = 2 Psi' LambdaCDM has a nonzero early ISW because Psi is still evolving at recombination (radiation matters). CR does not: C11 showed Psi is constant on L1.). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/ISW_line_of_sight.py`

P15R51 `M2_reabsorption_minimization` [OK]
sec:refit-bound (M2 — THE MINIMIZATION. Can a parameter refit absorb the damping shape? The honest core of the likelihood question, done on the closed forms derived in C8/C9 – no CAMB. SETUP, stated before running: FREE : Omega_m, omega_b, and the inherited datum rho_r/rho_m (which fixes z_onset). CONSTRAINT: l_* = pi D_M/r_s pinned to the observed 301 – the peak positions are measured.). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/M2_reabsorption_minimization.py`

P15R52 `PEEB_peebles_on_the_set_rate` [OK]
sec:refit-bound (PEEB — THE PEEBLES IONISATION HISTORY ON THE SET RATE. ZREC used Saha only: right shift, wrong absolute (1283 vs CAMB's 1090), because Saha has no departure from equilibrium. Peebles adds it – and the departure is itself H-dependent, which is exactly why it must be integrated on the construction's own rate rather than inherited. Standard effective three-level hydrogen atom (Peebles 1968; Seager et al. fits).). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/PEEB_peebles_on_the_set_rate.py`

P15R53 `ROBUST_p1p2_scan` [OK]
sec:refit-bound (**!! FIXED c54.160: THE REGISTERED COPY WAS UNRUNNABLE FROM ITS OWN DIRECTORY** – it imported 'RD_diffusion_direct', which lives only in 'storyboard_receipts/', so it exited 1 on ImportError before reaching any computation and the sweep had to run it from the ORIGIN instead. *A receipt that cannot run where it is registered is not a receipt.* Path resolution added; it now exits 0 in place). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/ROBUST_p1p2_scan.py`

P15R54 `P15_the_first_peak_figure_is_not_stable` [OK]
the acoustic sector (**THE 150 IS NOT A PREDICTION: 'ROBUST_p1p2_scan''s FIRST-PEAK POSITION AND PEAK-HEIGHT RATIO ARE NOT STABLE UNDER ITS OWN DOCUMENTED INITIAL CONDITIONS.** Built settling front #5, the corpus's two internal routes to the first acoustic peak (transfer 220, this instrument 150). **The front is posed as a disagreement between two established routes; one of the two is not established.** PART 1 the numerics are cleared first – stability number 0.47 against the file's own limit of 2.8, 120+ RK4 steps per oscillation, NS_CR x4 reproduces every figure. PART 2 Psi's VALUE comes from the smooth matched envelope and Psi's DERIVATIVE from the oscillatory closed form – two different functions, and the initial velocity is built entirely from the second. PART 3 across four readings of the SAME stated IC, ell_1 spans 150-315 and P1/P2 spans 0.93-2.02; **the reading the docstring actually describes ('velocities zero') returns 2.017 against the sky's 2.212, where the paper reported 1.45 as the disagreement.** PART 4 the comb the paper cites against it was never propagated either – 'verify_coherence_comb' writes down cos(k r_s) with r_s and D_C as literals. PART 5 **the residual: the source comb spacing is 0.72-0.79 of pi/r_s under EVERY variant. The initial data move the first peak by 165 multipoles and do not move this.**). *Computes:* stability asserted under the file's own 2.8 limit and steps-per-oscillation over 50; the two derivative functions asserted to differ by more than 1.2x across the band and to agree as x -¿ 0; the control asserted to reproduce 1.447 and 150/360/555/780; the documented-IC run asserted at 2.017 AND asserted closer to the sky than the implemented one; ell_1 asserted to move by 150+ multipoles and P1/P2 by more than 2x; the comb receipt asserted to contain cos(k r_s) and NO integrator; the comb deficit asserted present, bounded, and STABLE across variants (max-min ¡ 0.15) – which is what makes it not initial data. *Bound:* **scope: this does NOT vindicate 220 and supplies no first-peak position. It removes one route from arbiter status and registers the comb deficit, which is not resolved here. The four variant figures are produced by 'computations/beyond_the_wall/L171_what_sets_the_first_peak.py', which execs the registered receipt's own source with only the initial-data block substituted; its ICMODE=asis control reproduces the receipt exactly, assertions passing.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_first_peak_figure_is_`

P15R55 `P15_the_crossing_exists_and_is_empty` [OK]
the acoustic sector (**THE RE-ENTRY BETWEEN THE BRANCH POINT AND THE ONSET IS REAL, AND IT IS EMPTY: THE L1 POTENTIAL EQUATION CONTAINS NO k AT ALL.** Built working front #5, testing a candidate THIS FORK proposed at c54.165 – front #1 puts

every mode super-horizon and frozen at the branch point, 'prop:subhorizon' puts the acoustic modes inside at the onset, so they re-enter in between, and a crossing is where flat LCDM acquires its k-INDEPENDENT driving shift. **The answer is no, and the reason is stronger than the question.** PART 1 the re-entry is real and its boundary is computed: the mode crossing AT the onset is k = 0.0111/Mpc, ell = 144, so the peak modes crossed before the plasma began and ell ¡ 144 crosses after. PART 2 but it is a MATTER-era crossing – pressureless to better than a part in 1e4, because L1 has no radiation SOURCE. PART 3 **and the w = 0 potential equation has no k in it**: Phi constant to twelve digits, identical across four decades in k, the integrator taking the SAME number of steps for every mode. PART 4 the contrast: in LCDM 5 of 6 cross under radiation, where w = 1/3 restores the kˆ2 term and Phi decays on the sound-crossing time by construction.). *Computes:* every mode at/above the peak region asserted to cross before the onset AND ell = 28 asserted to cross AFTER it (the first draft claimed 'every observed mode' and this assertion fired); the boundary multipole asserted inside 100-250; the background asserted pressureless to 1e-3 at every crossing; Phi's spread across four decades in k asserted below 1e-9 AND the solver step count asserted identical across k; the LCDM contrast asserted to put 4+ modes under radiation with z_eq above 3000. *Bound:* **scope: this CLOSES a candidate mechanism and supplies none. It computes no peak position and uses no figure from the acoustic fold. It leaves 'PO-7' open and harder: the absence of a universal driving shift on this rate is not an omitted crossing but a scale-free interval.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_crossing_exists_and_is_empty.py`

P15R56 `P15_two_arm_control_and_guard` [OK]
the acoustic sector (**A LIVE LambdaCDM CONTROL AND AN UNDRIVEN GUARD, ON ONE MACHINERY – AND THE CR ARM'S FIRST PEAK SITS 23% LOW AGAINST A 1.5% POSITION FLOOR.** Built for fronts #5 and #18. **This fork had never run a control**: 'ROBUST_p1p2_scan' quotes one from r1975 in a comment, and c54.164 then showed its figures move over ell_1 in {150,165,315} with nothing to measure that against. PART 1 **the guard passes on BOTH arms** – every coupling to the potential removed at every site (4 Phi' in photon/neutrino/CDM continuity AND kˆ2 Psi in photon-baryon/neutrino Euler, both branches) and the source comb lands on the integers, LCDM 1.0147/2.0005 and CR 1.0121/1.9968, **so every departure from n pi/r_s in a driven run is the driving and nothing else**. PART 2 the control lands at 224/536/808/1116 against the sky's 220.6/538.1/809.8/1147.8 – **positions to 1.5% at the first peak and 0.4%/0.2% at the second and third; HEIGHTS only to 13-26%, so no height claim from this instrument is meaningful below ˜25%**. PART 3 the CR arm run on its PHYSICAL discrete ladder and on a dense continuum sampling gives **identical** peaks 172/396/624/904, so discreteness is not what sets the position – an objection closed by measurement. PART 4 ell_1/ell_A = 0.5703 against the control's 0.7433 and the sky's 0.7312: **a 23% deficit against a 1.5% floor, a factor of 15 in margin**, with P1/P2 = 0.866 against the control's 1.933.). *Computes:* the undriven comb asserted within 0.03 of the integers on both arms; the control's position floor asserted under 3% AND its second and third peaks asserted within 1% of the sky; the discrete and continuum peak lists asserted identical; the deficit asserted at 5+ floors; CR's ell_1/ell_A asserted in 0.55-0.60 and the control's in 0.72-0.76; the two arms' l_A asserted to agree to 1% (they do – D_M differs by 6.2% and r_s by 6.3% and they cancel). Every background quantity is RECOMPUTED rather than pinned. *Bound:* **scope: this does NOT settle 'PO-7' and the CR figure is not offered as a prediction – it uses the initial datum the corpus's own text describes (flat in k, common phase, VELOCITIES ZERO) and c54.164 established the figure moves with that choice. What changed is that it now moves against something. NO FIGURE FROM THE ABANDONED ACOUSTIC FORK IS USED; that fork's own reproduction gate fails in this tree, and this instrument disagrees with its 201.3 by 15%.** *Run:* `python3 receipts/P15_CR_cosmology/P15_two_arm_control_and_guard.py`

P15R57 `P15_the_driving_shift_by_subtraction` [OK]
the acoustic sector (**THE DRIVING SHIFT MEASURED MODEL-FREE BY SUBTRACTION: LCDM's ACOUSTIC PHASE IS FLAT IN k TO 2.1%, CR's VARIES BY 3.9x – AND THE SCALING IS kˆ-0.62, NOT THE kˆ-2 THE ABANDONED FORK'S MECHANISM REQUIRES.** Built for front #5 on the c54.168 instrument. Each k integrated TWICE on the same equations, driven and undriven, differing in one multiplicative switch and nothing else. Q(k) = k INT c_s deta/pi at the first acoustic turnover of Theta_0. **PART 1 the undriven column is the CALIBRATION and is MEASURED: 0.9968-1.0003 on both arms, where a free oscillator must give exactly 1.** PART 2/3 LCDM's Q_driven runs 0.791 -¿ 0.774 over k = 0.045-0.16

(2.1% spread) because every mode crosses under radiation, where the potential decays on the sound-crossing time by construction; CR's runs 0.457 -¿ 0.117, a factor of 3.9, because there is no radiation era to cross and c54.167 showed the pre-onset interval is scale-free. PART 4 **a power-law fit gives kˆ-0.62, collapsing the data to a factor of 1.2 where kˆ-2 spans a factor of 16.** The fold reports Q kˆ2 constant and its seam-transient mechanism (3H/kˆ2) requires it. **The phenomenon reproduces here independently; the exponent does not.** Recorded as an inter-instrument disagreement, not resolved.). *Computes:* the undriven calibration asserted within 0.01 of 1 on BOTH arms (this is the file's own gate); LCDM's spread asserted under 6%; CR's variation asserted over 2x; the fitted exponent asserted inside (-1.2,-0.3); **Q kˆ2 asserted to span MORE than a factor of 4 – i.e. the fold's constant-Q-kˆ2 asserted FALSE here**; and the fitted exponent asserted to collapse the data better than kˆ-2, so the fit is not vacuous. *Bound:* **scope: two corrections were forced by this file's own calibration and are recorded because each would have been a false result – (i) reading Q on Theta-hat rather than Theta_0 calibrated at 0.0003, since DR switches the couplings into the fluid but not Psi's own evolution; (ii) the driven LCDM column then calibrated at 0.001 on a decaying-mode transient two grid points from the start, excluded by requiring k eta ¿ 1, which is the DEFINITION of an acoustic turnover and removes nothing on the CR arm. No figure from the abandoned fork is used.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_driving_shift_by_subtraction.py`

P15R58 `P15_which_coupling_carries_the_k_dependence` [OK]
the acoustic sector (**THE k-DEPENDENCE LIVES IN THE POTENTIAL'S GRADIENT, NOT IN ITS DECAY – WHICH IS THE REVERSE OF WHERE A RELAXATION TIMESCALE WOULD PUT IT.** Front #5, on the c54.168 instrument against its 1.000 calibration. The potential enters the plasma TWICE: as '4 Phi" in continuity (its rate of change feeding the density – **the decay channel**) and as 'kˆ2 Psi' in Euler (its gradient driving the velocity). Switched independently on the same integration. PART 1 **flat LCDM's two couplings are each FLAT in k and they OPPOSE** – continuity alone puts the turnover at Q = 1.23-1.28, LATER than a free half-period, the gradient at 0.73-0.87, earlier, composing to 0.77-0.86. **So the universality of the standard driving shift is a CANCELLATION between two flat terms, not one term's signature.** PART 2/3 on the geometric rate there is no cancellation left – both advance (0.11-0.18 and 0.06-0.57) and they add – **and the k-dependence sits in the GRADIENT: continuity varies 1.6x at kˆ-0.17, gradient 8.9x at kˆ-1.04.** PART 4 and **neither term alone is the answer**: the driven exponent -0.62 lies BETWEEN the two, so the scaling is their interference.). *Computes:* LCDM's continuity asserted ABOVE 1 and its Euler BELOW 1 (they must oppose) and all three driven exponents asserted flat to 0.15; CR's continuity asserted nearly flat (|exp| ¡ 0.35) and its Euler steep (|exp| ¿ 0.8) and the Euler term asserted to be the steeper of the two – **reversing that assertion would reverse the finding**; both CR couplings asserted below 1 (they add); the driven exponent asserted strictly BETWEEN the two and distinct from each by 0.2; and the undriven calibration asserted within 0.01 of 1 on both arms, which is the file's own gate. *Bound:* **scope: this localises the k-dependence to a coupling and shows the standard shift's universality is a cancellation this rate does not have. It does NOT name the process that makes the gradient coupling run as kˆ-1, and computes no peak position. It closes the abandoned fork's stated mechanism as an explanation of THIS measurement – a relaxation on 3H/kˆ2 acts through the decay channel, and the decay channel is measured flat.** *Run:* `python3 receipts/P15_CR_cosmology/P15_which_coupling_carries_the_k_dependence.py`

P15R59 `P15_the_gradient_coupling_in_closed_form` [OK]
the acoustic sector (**THE GRADIENT COUPLING IN CLOSED FORM: THE TURNOVER IS AT A FIXED MULTIPLE OF 3H/kˆ2, AND SINCE Q ALREADY CARRIES ONE FACTOR OF k THAT GIVES Q ˜ 1/k, NOT 1/kˆ2.** Front #5, closing the question c54.170 left. **The derivation is four lines.** (1) Phi's own equation carries a damping term -kˆ2 Phi/3H, so Phi relaxes on tau = 3H/kˆ2. (2) With continuity off the oscillator is Theta_0" + c_sˆ2 kˆ2 Theta_0 = -(kˆ2/3) Psi, and **the kˆ2 in the forcing's amplitude is cancelled by the kˆ-2 in its duration – the delivered impulse is k-INDEPENDENT**. (3) So the first turnover is at the moment the impulse has been delivered, at a fixed multiple of tau: kappa = 1.79, constant across a factor of eight in k. (4) Q = k INT c_s deta/pi already carries one k, so **Q = 3 kappa c_s H/(pi k)**. **PREDICTED Q k = 0.010403/Mpc AGAINST A MEASURED 0.010372 – 0.30% – with nothing fitted but kappa; and the closed form reproduces Q itself to 1.6% across the sub-horizon band.** ⇒ **The abandoned fork's TIMESCALE is right and its EXPONENT is out by exactly

one factor of k – a bookkeeping error in its own mechanism rather than a disagreement about physics.** And the continuity channel is flat for the complementary reason: '4 Phi'' feeds the density with the potential's TOTAL change, INT Phi' deta = -Phi_0, the same however fast the relaxation runs. **So the observed k^-0.62 is not a power law of anything – it is the crossover between a flat channel and a 1/k one.**). *Computes:* kappa asserted constant to 10% across the sub-horizon band; **the flattest grouping asserted to be Q k^1 and not Q k^0 or Q k^2 – if that assertion reverses, the derivation is wrong**; the predicted coefficient asserted within 5% of the measured one; the closed form asserted to reproduce Q to 5% across the band; the continuity channel asserted flattest UNGROUPED and asserted flat to within a factor of 2. *Bound:* **scope: this NAMES the process, so front #5's question is answered. It does NOT make the first peak agree with the sky – the 23% deficit against a 1.5% control floor stands unchanged. What changed is that its cause is derived rather than described. No figure from the abandoned fork is used; its timescale is confirmed independently here and its exponent corrected.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_gradient_coupling_in_closed_form.py`

P15R60 `P15_where_the_likelihood_sits` [OK]

the acoustic sector (**WHERE THE LIKELIHOOD ACTUALLY SITS: IT CANNOT ARBITRATE, AND THE INSTRUMENT'S OWN CONTROL IS WHY.** Discharges 'L-147', fenced since it opened on three conditions – falsifier fixed before any data is touched, a control reproducing a known number first, and not until the two internal routes agree. **All three met** (the routes collapsed at c54.164-168), so the fence came down. **F1** the pipeline is wired: the banked CAMB flat-LCDM best fit returns chi^2 = 206.4 over 215 plik_lite TT bins, chi^2/dof = 0.96. **F2** the instrument's own floor, measured through the SAME likelihood on the SAME bins: this fork's LCDM arm costs +18786 over CAMB. **F3** the only readable quantity, both arms of one instrument: CR - LCDM = +84160. **F4** the pre-registered rule returned 'suggestive, not a measurement discrepancy'. **F6 – AND THE PRE-REGISTERED RULE WAS DEFECTIVE, WHICH RUNNING IT IS WHAT SHOWED.** It is a RATIO test and never asks whether the floor is small in ABSOLUTE terms. It is not: the control arm sits at **chi^2/dof = 103** against CAMB's 0.96, because Planck's binned errors are a few tenths of a per cent and this instrument's heights carry 13-26%. **Both arms are far outside the regime where plik_lite discriminates, so the honest verdict is the WEAKER one: the likelihood cannot arbitrate.** **!! That correction happens to FAVOUR the construction and is flagged for it** – it would apply identically had the CR arm come out better, and it rests on a height floor measured at c54.168 before any data were opened. **What survives as fact: on one instrument, same bins, same fitted amplitude, the CR arm costs 5.4x the LCDM arm's chi^2. An ordering, not a p-value.**). *Computes:* the banked LCDM fit asserted at chi^2/dof in (0.85,1.15) BEFORE anything else is read; every covered bin asserted non-empty (the keep mask); the instrument floor asserted POSITIVE (this instrument cannot beat a five-parameter CAMB fit, and if it appeared to, the binning would be wrong); the CR arm asserted to cost more than the control on the same instrument; and **F6's premise asserted – if the control arm ever drops below chi^2/dof = 3 the PART must be rewritten because the likelihood then CAN arbitrate.** *Bound:* **scope: plik_lite TT only – no polarisation, no ell ¡ 30, no lensing, no external priors, a third-party implementation rather than clik (PROVENANCE.md), and 185 of 215 bins because the instrument reaches ell = 2000. The restriction to covered bins is done on the COVARIANCE and re-inverted, which MARGINALISES over the missing multipoles; dropping rows of the Fisher matrix would CONDITION on them. The banked r1934 CR figure (397.1 vs 206.4) applied the derived DAMPING suppression to CAMB's LCDM spectrum – it tested damping on LCDM's PEAK POSITIONS and could not have seen the position result, so it answers a different question and is SUPERSEDED here. 'PO-7' stays protected: this reports a number and does not convert it into a verdict.** *Run:* `python3 receipts/P15_CR_cosmology/P15_where_the_likelihood_sits.py`

P15R61 `P15_the_line_of_sight_transfer` [OK]

the acoustic sector (**THE TRANSFER REBUILT ON A LINE-OF-SIGHT INTEGRAL: THE CONTROL'S FIRST-PEAK POSITION ERROR FALLS FROM 1.66% TO 0.16%, AND THE CR DEFICIT DOES NOT MOVE AT ALL.** Front #2. Until c54.173 the source was evaluated at a SINGLE eta_rec – an instantaneous last scattering. **The visibility g = tau' e^-tau peaks at eta = 280.75 with FWHM 37.8 Mpc, a tenth of a wavelength at the first peak.** Rebuilt as Delta_l = INT S j_l deta with S = g(Theta_0+Psi) + e^-tau(Phi'+Psi') + (1/k^2) d/deta[g theta_b]. PART 1 the control goes 1.66% -¿ 0.16% in ell_1/ell_A: **sub-per-cent POSITIONS, which is what the likelihood needed of them.** PART 2 **and the CR arm is unchanged to four figures, 0.5703 on both transfers, while the control moved 1.79%. The deficit stands at 21.9% against a 0.16% floor – 134 floors.** The most suspect part of the instrument was replaced wholesale and the number did not follow it down. PART 3 **the heights are NOT fixed and the target is NOT met**: P1/P2 -13%, P1/P3 -34%, a residual growing with multipole and pointing at the damping tail (no polarisation term; a tight-coupling closure that fails where the visibility is). Stated as a partial result. PART 4 one correction was a DERIVATION: the Doppler term carries 1/kˆ2 not 1/k, since v_b = theta_b/k. **With 1/k the second peak sat at 516 and P1/P2 at 3.15; with 1/kˆ2, 532 and 1.93 – and ell_1 was 220 either way, so an instrument validated on the first peak alone would have carried the error.**). *Computes:* the control's position error asserted sub-per-cent AND asserted improved by 5x or more; the CR arm asserted to move less than 1% under the rebuild; the deficit asserted at 20+ floors; **the heights asserted NOT sub-per-cent – if they ever are, the PART is stale and front #2 should be struck**; and the corrected Doppler power asserted to move the SECOND peak toward the sky, which is what makes it a fix rather than a tuning. *Bound:* **scope: this delivers sub-per-cent POSITIONS and leaves the HEIGHTS at 13-34%, so the likelihood still cannot be run (c54.172). The remaining error is a high-multipole problem and neither of its two named causes is a CR question – both are checked against the LambdaCDM arm first. Late ISW is truncated at eta = 4000, which affects only ell below ˜30 and is outside both the grid and plik_lite's TT range.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_line_of_sight_transfer.py`

P15R62 `P15_the_derived_diffusion_damping` [OK]
the acoustic sector (**THE HEIGHTS FROM 13-34% TO 2-3%: THE DIFFUSION DAMPING PUT BACK, DERIVED ON EACH ARM'S OWN OPACITY AND RATE.** Front #2. **Diagnosed from the SIGN**: at c54.173 both height ratios were LOW, meaning peaks 2 and 3 too HIGH, worse at higher multipole – under-damping. **The hierarchy's tight-coupling closure switches off at tau' = 0.6/Mpc and the visibility peaks at tau' = 0.06/Mpc, ten times lower, so the photon quadrupole and the baryon slip were absent through the WHOLE of last scattering and the line-of-sight path carried no Silk damping at all.** The pre-LOS path hid this behind a hardcoded r_D. PART 1 the standard tight-coupling integral 1/k_Dˆ2 = INT [Rˆ2/(1+R) + 8/9]/[6(1+R)tau'] deta, evaluated on this arm's own background: **r_D = 6.58 Mpc against the 6-7 a Boltzmann code gives. Nothing fitted.** PART 2 **and a DOUBLE COUNT had to be removed**: with the hierarchy's own damping left in over tau' ¿ 0.6 AND the integral covering the same range, the control came out OVER-damped (+6.7%, +17%). **The sign flips either side of the correction, which identifies a double count rather than a wrong coefficient.** PART 3 heights **-12.9%/-33.5% -¿ -2.8%/-2.1%**, on a control whose positions were already sub-per-cent. PART 4 **and the likelihood's floor falls 103 -¿ 23 in chiˆ2/dof, a factor of 4.6, WITHOUT the verdict turning over** – 'L-147''s answer stands, and the floor moving while the verdict does not is what measures how far the instrument still has to go.). *Computes:* r_D asserted inside 5.5-8 Mpc; tau' at the visibility peak asserted BELOW the gate (PART 1's premise); **the sign asserted to flip either side of the correction – if it does not, it is a coefficient error and not a double count**; the single-mechanism heights asserted within 5% and asserted better than BOTH the no-damping and the double-counted runs; the floor asserted to fall by 3x or more; **and the control asserted to remain ABOVE chiˆ2/dof = 2 – if it ever drops below, the likelihood CAN arbitrate and 'L-147''s verdict must be revisited.** *Bound:* **scope: this does not reach sub-per-cent heights and does not make the likelihood answerable. The residual is still worst at high multipole: no polarisation term in the source, and a photon sector with no free-streaming hierarchy after decoupling. Neither is a CR question.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_derived_diffusion_damping.py`

P15R63 `P15_the_height_target_was_below_the_resolution_of_its_own_statistic` [OK]
the acoustic sector (**THE HEIGHT TARGET WAS QUOTED AGAINST A SKY NUMBER WITH A 3.4% ERROR BAR THAT WAS NEVER WRITTEN DOWN, AND chiˆ2 – THE STATISTIC THAT CAN SEE – PREFERS A COEFFICIENT IT IS NOT ALLOWED TO CHOOSE.** Front #2. Since c54.168 every height claim here (-13%, -34%, 2-3%, -0.05%) compared P1/P2 and P1/P3 to two bare numbers, 2.217 and 2.277. **PART 1** the numerics are cleared first: 1.4x the modes, 1.3x the k-range and 1.8x the eta-sampling move the ratios by 0.09% and 0.37%, and the 2%/7% swings that prompted the check came from LMAXL=1300 truncating the k integral under the THIRD peak. **PART 2** read off the plik_lite bandpowers with the published covariance – the full 2x2 block, not a diagonal estimate – **the sky's own ratios are 2.256 +- 0.077 and 2.280 +- 0.074: 3.4% and 3.2%.** So the 13% and 34% of c54.173 were

four and ten sigma and stand; **the 2-3% of c54.175 are about one sigma and do not.** *Caught by bookkeeping and not by suspicion: X_data is binned C_l and not D_l, so peak-finding on it returned 464/761/1085 instead of 221/527/815.* **PART 3** a scan of one multiplier on 1/k_D^2 has P1/P2 selecting 1.094 +- 0.184 and P1/P3 selecting 0.897 +- 0.055 – **a 1.03 sigma split, so my own 'no single scale fits both, the residual is the envelope's SHAPE' is WITHDRAWN at its own error bar rather than published.** **PART 4** chi^2 over 185 bins does separate them: the minimum sits at 0.865 against 8/9's 0.859, and 16/15 costs 1123 units, seven inflated sigma. **The coefficient is changed back to 8/9 and NOT because it fits better** – neither value has ever been derived here (C8_diffusion_length names the ambiguity in its own text), and a remembered number is not a derivation any more than a fitted one is. **PART 5** L-147's pinned chi^2 came from a script in /tmp; 'chi2_of_spectrum.py' puts that machinery in the corpus and returns 4170.2 and 50675.2 exactly.). *Computes:* converged spread asserted under 1% and the truncated run asserted separated from it; the sky's recomputed ratios asserted within 1 sigma of the bare numbers they replace; the DAMPX multiplier asserted to reproduce the explicit POLC=8/9 run to 0.2%; **the withdrawal asserted: if the split were 2 sigma or more the file FAILS for retracting a claim that in fact holds**; the chi^2 minimum asserted at the 8/9 multiplier within 5%; both pinned values asserted recomputed to 0.5%; and an assert that fires if the control ever reaches chi^2/dof ~ 1, since this file would then need rewriting rather than patching *Bound:* **scope: this corrects a MEASUREMENT PROTOCOL, not the construction, and it is a correction to my own work. It supplies no derivation of the shear coefficient – that is named as owed and is front #2's first item: the free-streaming photon hierarchy with the polarisation multipoles. And the 3.2-3.4% is the single-bandpower-bin resolution; a full-curve fit determines the peaks far better, which is exactly why chi^2 replaces the ratios rather than joining them.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_height_target_was_below_the_resolution_of_its_own_statistic.py`

P15R64 `P15_the_shear_coefficient_derived_not_remembered` [OK]
the acoustic sector (**THE DIFFUSION-DAMPING SHEAR COEFFICIENT, DERIVED FROM THE POLARISED PHOTON HIERARCHY INSTEAD OF REMEMBERED OR FITTED – AND ADOPTING IT COSTS THE CONTROL 1123 UNITS OF chi^2.** Front #2, closing the item c54.176 named as owed. 'C8_diffusion_length' has named 'the 8/9 coefficient against the 16/15 polarization-corrected one' in its own text since it was written, and neither had ever been derived here. **METHOD** two integrations of the same oscillator on the same background: the perfect tight-coupled fluid, undamped by construction, against photons carried to l = 24 with Thomson scattering, the polarisation multipoles evolved alongside and the baryons on their own velocity. **Their ratio is the damping and nothing else – the (1+R)^(1/4) WKB prefactor, the drift of c_s and the R-dependence of the oscillation are common to both and divide out identically.** Gravity is off in both, which is the definition of the object rather than an approximation. **PARTS 1-4** with G = 0 the l=2 term is -(9/10)tau'F_2, the textbook unpolarised closure, and C = 0.8852 against 8/9; with polarisation C = 1.0618 against 16/15; **and the polarisation correction – the quantity actually in dispute – is a factor 1.1996 against 6/5, three parts in ten thousand.** C is read LOCALLY between consecutive extrema and extrapolated in (k/tau')^2, so the k^2 scaling is measured rather than imposed. **PART 5** 16/15 is adopted and the control's floor goes 22.5 -¿ 28.6. **The fit's preference for 8/9, measured and refused at c54.176, is refused again: a coefficient chosen because it fits is a fitted parameter whatever it is called.** **PART 6** and nothing downstream moves – sec:envelope-consequence's 10.8% goes +10.83% -¿ +10.87%, because the coefficient nearly cancels in a ratio of two rates.). *Computes:* both intercepts asserted within 2% of the leading-order values and pinned to ~1% in the gate; **the polarisation correction asserted within 0.5% of 6/5 and pinned to a tenth of a per cent – it is the number the file exists to produce**; the scatter about the line in (k/tau')^2 asserted below 0.01, so a method that destroyed the extrapolation fails rather than shifting the intercept quietly; the sign of the finite-(k/tau') correction asserted, and the extrapolation asserted SHORT (under 2% of the coefficient swept over the fitted range); **the chi^2 cost asserted POSITIVE – if the derived coefficient stopped costing chi^2 the file's whole point would need restating**; and the C8 figure asserted to move less than a tenth of a point, so adopting the coefficient cannot silently shift a published number *Bound:* **scope: this derives the coefficient in the WKB damping integral and NOT the damping envelope's shape. It supplies the damping half of the polarisation physics only; the SOURCE half – g*Pi/4 and (3/4k^2)(g*Pi)" with Pi = Theta_2 + Theta^P_0 + Theta^P_2 – needs the hierarchy carried in the spectrum instrument and is what front #2 still owes. And one assertion of mine fired on its own data: I demanded

both extrapolation slopes be of order unity and they are -0.150 and -0.942; the gate now checks that the extrapolation is SHORT, which is the thing that actually matters.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_shear_coefficient_derived_not_remembered.py`

P15R65 `P15_the_photon_hierarchy_in_the_transfer` [OK]
the acoustic sector (**THE PHOTON BOLTZMANN HIERARCHY WITH POLARISATION CARRIED INSIDE THE TRANSFER: THE CONTROL'S chiˆ2/dof FALLS 28.6 -¿ 7.1 AND THE FIRST FOUR PEAKS LAND AT 220/540/812/1124 AGAINST THE SKY'S 220.6/538.1/809.8/1147.8.** Front #2. Photons as multipoles to l = 24 with the polarisation hierarchy alongside, the baryons on their OWN velocity and their OWN density, and the source carrying g*Pi/4 and (3/4kˆ2)(g*Pi)". **THE HANDOVER MAKES A DOUBLE COUNT IMPOSSIBLE RATHER THAN MERELY ABSENT**: the fluid runs to tau' = 3/Mpc and the envelope is FROZEN there, so envelope and multipoles have disjoint supports – and only 4.2% of 1/k_Dˆ2 has accumulated at the handover, so 96% of the damping is dynamic. **PART 1** the second peak is 0.35% out and the third 0.27%, where the fluid had them 2.6% and 0.7% low. **PART 2** chiˆ2/dof 28.6 -¿ 7.1, and 20.0 -¿ 4.2 over the range where the wavenumber integral is not starved. **PART 3** and c54.177's prediction is checked against the number it predicted: **running the same hierarchy with ONLY the two polarisation source terms dropped – exactly the half an envelope has – gives 2022 against 1320, so they are worth Delta chiˆ2 = 702, 63% of the 1123 that adopting the derived 16/15 cost.** **PART 4** and half the baryon split is WORSE than none: own density while still sharing the photons' velocity moved chiˆ2/dof 133 -¿ 161 at development settings; both halves give 15.1 -¿ 7.1. *Twice now a physical effect taken in half has been worse than not taken – it is not a small error but a different and inconsistent model.* **PART 5** doubling the hierarchy depth moves chiˆ2 by 0.00% and doubling the handover opacity by 1.5%. **PART 6** and the CR arm is at ell_1/ell_A = 0.5703 for the SIXTH instrument state, while the control improved fourfold.). *Computes:* every peak asserted no FURTHER from the sky than the fluid transfer's; the chiˆ2 improvement asserted to be at least a factor of two and pinned at 7.14 / 4.17; both height ratios asserted within 2 sigma of the sky's own covariance-derived values; **the polarisation source terms asserted to recover between 40% and 120% of c54.177's 1123 – outside that range c54.177's statement could not be said to have predicted this and the file FAILS**; the full baryon split asserted to beat the shared-density run; the LG and handover sensitivities asserted below 0.1% and 5%; the CR arm asserted unmoved to the fourth decimal; and an assert that fires if the control ever reaches chiˆ2/dof ˜ 1, since L-147 would then have to be REOPENED rather than this file's closing line printed *Bound:* **scope: this is the LambdaCDM control and the CR arm on one instrument, and it converts nothing into a verdict – 'PO-7' is protected and 'L-147''s answer is unchanged, because a control at seven times a fit still cannot certify what it is compared with. What remains is accuracy and no longer a named missing SECTOR: reionisation, neutrino mass, lensing, and the wavenumber range. And the aliasing gate was found MISSING from the line-of-sight path, which has been the default since c54.173; it cost a development run a first peak at 196 instead of 220 with nothing said, and is now on both paths.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_photon_hierarchy_in_the_transfer.py`

P15R66 `P15_what_is_left_is_lensing_and_not_reionisation` [OK]
sec:refit-bound (**BOTH OF FRONT #2's NAMED NEXT STEPS MEASURED BEFORE EITHER WAS BUILT, AND ONE IS WORTH EXACTLY NOTHING.** **PART 1** above ell ˜ 40 reionisation's whole TT effect is the constant screening exp(-2 tau), and the amplitude here is fitted in CLOSED FORM – A = (m F d)/(m F m) is homogeneous of degree -1 in m, so m -¿ s m returns A/s and the residual is IDENTICAL. **d(chiˆ2) = 0 exactly, shown at tau = 0.054, 0.10 and 0.30, zero to machine precision at all three.** *The degeneracy is a property of the STATISTIC, not of the size of tau.* **PARTS 2/3** a Gaussian smoothing in ell, width scanned, minimises at chiˆ2 = 921 against the control's 1320 – and **a width that GROWS with ell beats a constant one by 1.8x in d(chiˆ2), 400 against 225, each at its OWN optimum so the comparison is of SHAPE**. Lensing smooths more at high ell because a deflection of fixed angle subtends a larger fraction of an acoustic wavelength, and that is the signature the data select. **PART 4** the width is FITTED, so the 400 bounds what a DERIVED calculation has to play for and is not a measurement of the lensing amplitude – **and ˜921 of the 1320 survives it, so lensing is the next build and is NOT the last one.**). *Computes:* the reionisation degeneracy asserted EXACT – if it ever moves chiˆ2 the amplitude is no longer fitted in closed form and PART 1's algebra no longer describes the pipeline; both smoothing optima pinned; **the growing width asserted to beat the

constant one by at least 1.5x, which is the SHAPE claim and the reason the word is 'lensing' rather than 'some smoothing'**; what survives asserted above 60% of the baseline, so a rewrite is forced rather than a patch if a fitted smoothing ever accounts for most of the residual; and an assert that fires if a smoothing alone would take the control to chi^2/dof ¡ 2, since L-147 would then have to be revisited *Bound:* **scope: this measures what two candidate builds can be worth on THIS statistic. It is not a result about the sky, not a measurement of the lensing amplitude, and the control does not improve – the smoothing width is fitted. Reionisation is STRUCK from the front's list rather than deferred, and the condition that would undo the strike is written down: a comparison reaching ell ¡ 30, a second spectrum, or a fixed amplitude.** *Run:* `python3 receipts/P15_CR_cosmology/P15_what_is_left_is_lensing_and_not_reionisation.py`

P15R67 `P15_derived_lensing_on_the_lcdm_arm` [OK]
sec:refit-bound (**THE DERIVED LENSING c54.181 TEED UP, RUN WITH NO FREE WIDTH – AND IT COMES IN UNDER THE FITTED BOUND, WHICH IS WHAT A DERIVATION MUST DO.** ΛCDM's own non-perturbative lensed/unlensed ratio applied to the c54.178 LCDM arm takes the control 1320 -¿ 989, d(chi^2) = 331 – UNDER the 400 the c54.181 fitted smoothing bounded, and concentrated in the damping tail (ell 1100-1500) where lensing fills the troughs. The acoustic peaks move 0.0%. The corpus's own first-order Hu (2000) kernel, run on the SAME C^phiphi so only the ORDER differs, OVERSHOOTS to 508 because it BREAKS DOWN in the tail – a spurious +13% at ell=1900 against the full operator's +6.5% – so the derived number is the full operator's 331, not the first order's 508. Validated on CAMB's own LCDM: 615 unlensed -¿ 186 lensed (chi^2/dof ~ 1). ~989 of 1320 survives, so lensing is real and NOT the last build.). *Computes:* lensed CAMB LCDM asserted at chi^2/dof in (0.75,1.25) so the operator and pipeline are validated before anything is read off the arm; the derived lensing on the arm asserted in (280,385) AND strictly under the c54.181 fitted bound of 400, which is the defining property of a zero-width derivation against a fitted upper bound; the first-order kernel asserted to OVERSHOOT the full operator by more than 80 in d(chi^2) via the tail artefact, a live check that LENS_correction is first order and that the tail is where it fails; and the peak shift asserted below 0.3%. *Bound:* **scope: the lensing operator is ΛCDM's, imposed not fitted, so this is not a measurement of the lensing amplitude and the CR arm does not fit – it measures how much of c54.181's fitted-smoothing headroom a genuine zero-parameter lensing recovers (most of it), with the shortfall against the fit being the fit's free width. The residual ~989 is the instrument's transfer inaccuracy, not lensing's: CAMB's UNLENSED LCDM already sits at 615 on these same bins. 'PO-7' stays protected.** *Run:* `python3 receipts/P15_CR_cosmology/P15_derived_lensing_on_the_lcdm_arm.py`

P15R68 `UNC_error_budget` [OK]
sec:refit-bound (UNC — QUANTIFYING WHAT WE DO NOT KNOW. The prediction with an error budget. Corrections folded in first: * the recombination WIDTH scales with the rate (A.22) – so the thickness contributes ~nothing to the RATIO and the signature is carried by r_D essentially alone; * the l_D anchor affects only the ABSOLUTE r_D and cancels in the ratio – it carries NO uncertainty into the prediction;). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/UNC_error_budget.py`

P15R69 `P15_the_residual_is_contrast_and_the_lensing_potential_is_derived` [OK]
sec:refit-bound (**WHAT THE CONTROL'S REMAINING chi^2 IS MADE OF, AND THE LENSING POTENTIAL BUILT TO ATTACK IT.** **PART A** templates projected through the same inverse covariance the chi^2 uses: **positions remove 1.4 of 1320 – 0.1%, so the peaks are where the sky puts them and that is not where the residual lives**; a smooth envelope 15%; **the peak-trough oscillation at FIXED position 38%, with the model's contrast 13.1% TOO HIGH** – which is what lensing reduces; and **53% in NEITHER, so a perfect lensing calculation leaves about half**. *Fitted templates, so each share is an upper bound on what the effect can claim.* **PART B** the line-of-sight solve stops at z = 12.8 but the lensing kernel peaks at z ~ 3.3, so Phi is carried on by the background's own growth factor D prop. H INT da/(aH)^3 – exact in linear theory, no transfer function imported, k-dependence from this instrument's own Phi. **And the normalisation is the amplitude the TEMPERATURE comparison already fits, so lensing enters with NO new parameter.** Limber checked against an EXACT projection (5% over l = 5-200); the deflection maximum is BROAD, within 10% over l = 12-42; **rms deflection 2.69 arcmin with nothing tuned to it.**). *Computes:* positions asserted below 2% of the residual, so the diagnosis reorders loudly if they ever rise; the contrast excess pinned to 13.1% +- 2 points, since that is

what the convolution must remove; what survives BOTH template sets asserted at 53% +- 5, **so a build that forgets how much remains fails here**; Limber's departure asserted below 10%, since the convolution will use it; the deflection maximum asserted BROAD; and the absolute rms deflection pinned at 2.692 arcmin, which is the zero-parameter check on the normalisation *Bound:* **scope: PART A's shares are FITTED-template upper bounds, not measurements of physical effects, and the two sets overlap by ~7 points. And PART B's external agreement is weaker than it looks: the ~2.7 arcmin and the ~1e-7 deflection power it matches are RECALLED, not derived here and not checked against a source this corpus holds – this programme was bitten twice in three revisions by exactly that (the 16/15 coefficient at c54.176, and a Limber suspicion in this very file which was also recollection and also wrong). What PART B establishes is INTERNAL consistency; the external agreement is corroboration at the strength of a memory.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_residual_is_contrast_and_the_lensing_potential_is_derived.py`

P15R70 `P15_the_phase_is_the_driving_and_the_undriven_arms_agree` [OK]
sec:refit-bound (**WHY 0.62 pi: THE DRIVING — AND THE ATTRIBUTION IS COMPLETE. WITH EVERY COUPLING TO THE POTENTIAL REMOVED THE TWO ARMS' ACOUSTIC PHASES AGREE TO 0.013 OF l_A.** Front #2, lead 'L-507'. c54.191 closed with *"an acoustic phase shift is a computable consequence of the driving, so 'why 0.62 pi' has an address. This file does not have it."* **The instrument has carried the switch since c54.170** — 'NODRIVE=1' removes every coupling to the potential at every site (the 4·Phi' in the photon, neutrino and CDM continuity equations and the k^2·Psi in the Euler equations) while leaving Phi's own evolution alone, that being the background and not a coupling. *Both arms run through it at production depth here, which no revision had done.* **PART 1 UNDRIVEN THE TWO ARMS ARE THE SAME OSCILLATOR:** intercepts **−0.135 and −0.149 of l_A — agreeing to 0.013** — and both slopes l_A to a part in a thousand. *Two constructions with different rates, sound horizons, starting redshifts and initial data give the SAME acoustic series once nothing drives it.* **PART 2 AND THE DRIVING IS WHAT SEPARATES THEM:** switched on it supplies **−0.127 to the control and −0.729 here, a factor of 5.7**; the driven discrepancy is 0.615 and the undriven 0.013, so **the driving accounts for 98% of it**. **PART 3 THE SAME SWITCH ACCOUNTS FOR THE SPACING:** undriven both slopes are 1.000 and 1.001 of l_A; driven, the control's is 1.003 and this construction's 0.976 — **so the 2.4% the spacing was short is the driving as well, and not a second effect**. ⇒ ***THE WHOLE ACOUSTIC DISAGREEMENT IS ONE COUPLING BEHAVING DIFFERENTLY — and a coupling is a thing a theory says something about, where a ratio is not.*** ***PART-HEADLINE CORRECTED c54.195 ('L-508'): the 0.62 pi is the value at phi = 0. Across four seam phases at production depth the asymptotic phase spans 0.891 and the CONTROL'S VALUE LIES INSIDE that span, so it is not a prediction. The driving ATTRIBUTION stands; its promotion to "the whole disagreement" does not.***). *Computes:* **the UNDRIVEN agreement asserted under 0.10 of l_A — if the arms still differed with nothing driving them the driving would not be the whole story and PART 2's headline would be wrong**; the ratio of what the driving supplies asserted above 3x and pinned at 5.7 +- 1.5, without which PART 2 has no content; **the undriven SLOPES asserted at l_A to 1%, which is what makes PART 3's "not a second effect" true**; the driven discrepancy re-derived at 0.615 +- 0.05, tying this file to 'L-505' and 'L-506'; the driving's share asserted above 85%; and at least seven peaks per arm *Bound:* **scope: an ATTRIBUTION is not an explanation and it is not a verdict. What this establishes is that the acoustic disagreement lives in ONE COUPLING rather than in four items, a ratio, or an initial condition. IT DOES NOT SAY WHY the driving is 5.7x stronger here — the obvious candidate is that this construction's modes begin already sub-horizon at the seam carrying an assigned amplitude and ZERO velocity, in a potential that is not the equilibrium configuration for that state, where the control's begin super-horizon in adiabatic equilibrium; **that is a HYPOTHESIS and this file does not test it**. The instrument carries the split that would: 'DRC' is the potential's rate of change feeding the density and 'DRE' its gradient driving the velocity, switchable separately — the next thing this front owes. 'F5' unsoftened; 'PO-7' protected; the conversion runs by 'F5''s stated procedure.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_phase_is_the_driving_and_the_undriven_arms_agree.py`

P15R71 `P15_the_phase_moves_with_the_datum_and_only_the_spacing_does_not` [OK]
sec:refit-bound (**THE OBSERVER LINE'S ITEM 38 ANSWERED, AND THE ANSWER WITHDRAWS c54.190–191's HEADLINE. ACROSS FOUR SEAM PHASES AT PRODUCTION DEPTH THE ASYMPTOTIC ACOUSTIC PHASE SPANS 0.891 IN phi/pi — AND THE CON-

TROL'S 0.263 LIES INSIDE THAT SPAN.** Front #2, lead 'L-508'. *Item 38 (r2485): of the 23 datum-scan spectra ZERO reach peak 8, so the quantity carrying the disagreement could not be tested against the one freedom known to move things. It named the experiment — two or three seam phases at production depth. c54.191 supplied one; this supplies two more.* **PART 1** at phi = 0, pi/4, pi/2 and pi the fitted phi/pi is **0.878, 0.958, 0.066, 0.671** — *c54.191 read 34% closure from the two endpoints; **the interior is where the motion is***. **PART 2 SO 0.62 pi IS THE VALUE AT ONE READING AND NOT A PREDICTION.** *The attribution to the driving (c54.193) stands — the driving is what separates the arms AT A GIVEN READING — but a quantity the datum can move across the control's value is not a prediction of the construction.* **PART 3 THE HEIGHTS MOVE TOO:** P1/P2 runs **0.483 → 1.618** against the sky's 2.217 and the control's 2.197, and **never reaches it**. **PART 4 WHAT IS ROBUST IS THE SPACING:** 0.9629–0.9814 of l_A over the same four — **1.9%** — and tracking r_s at 98% of the acoustic rate under the fitted parameter. **PART 5 AND MATCHING THE PHASE DOES NOT FIX THE SPECTRUM**, which is what settles PART 2: the reading closest in phase (phi = pi/2, a phase gap of 0.197) has **chi^2/dof = 224 against the control's 3.71 on the same 185 bins — sixty times worse while agreeing on the phase**. ⇒ ***So the phase was never carrying the disagreement.***). *Computes:* **the control's phase asserted INSIDE the span the seam phase reaches — without which there is no withdrawal and c54.190–191 stand as written**; the span asserted above 0.3 and pinned at 0.891, which IS item 38's question; **the low-ell transient asserted present in ALL FOUR at more than 3x the control's — this is what establishes the peak INDEXING, and if a reading showed none the span could be an artefact of labelling**; the spacing's stability asserted under 6%, the one thing this file does NOT withdraw; the heights asserted never to reach the sky's; and **the phase-matched reading asserted above 10x the control — PART 5 is what makes the withdrawal a finding rather than a shrug** *Bound:* **scope: this is the THIRD withdrawal of this line's own headline in the span, and it is forced by the data rather than chosen. What it leaves is worse than c54.191 reported and truer: the acoustic SPACING is right and robust; the acoustic PHASE and the peak HEIGHTS both move substantially with a datum the corpus does not fix and neither reaches the sky at any reading tried; and no reading brings the spectrum within sixty times the control. **Where the disagreement lives is therefore not a single named quantity and this file does not supply one.** 'F5' unsoftened and it cuts both ways — a discrepancy resting on a free choice is not a framework verdict either. 'PO-7' protected; the conversion runs by 'F5''s stated procedure.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_phase_moves_with_the_datum_and_only_the_spacing_does_not.py`

P15R72 `P15_the_locus_was_wrong_in_six_places_and_the_lint_could_not_see_the_worst` [OK]
sec:perturbations, sec:coherence, sec:envelope (**ROUTED ITEM 21 WORKED: SIX SITES SAID "BRANCH POINT" WHERE THEIR OWN RECEIPTS SAY "SEAM"/"ONSET", AND THE PHYSICS INVERTS BETWEEN THE TWO — SO A PROPOSITION TITLED "SUB-HORIZON" WAS TRUE AT ONE AND FALSE AT THE OTHER. AND THE LINT BUILT FOR THIS DEFECT COULD NOT SEE THE WORST OF THEM.** Front #2, lead 'L-509'; VEIN 'L-202'. **PART 1 THE INVERSION, RE-DERIVED FROM THE METRIC FUNCTION** rather than taken from the routing slip: normalised 1/aH is **1.000 at the seam and 0.051 toward r=0**, and with the inherited datum the horizon maximum sits at **r* = 1.5338 r_seam, just OUTSIDE the seam** — so the seam is on the rising branch and the acoustic modes are already inside there, which is a *derivation* of prop:subhorizon and not a numerical coincidence of z_onset. **PART 2 SIX SITES REPAIRED, PINNED BY TEXT AND NOT BY LINE NUMBER** — including the subsection heading, *which contradicted its own proposition three lines below*, and the sec:envelope sentence *that claims to BE the derivation, with the locus backwards*. **One of the six was not on the routed item's list**; the lint found it. **The one true-as-written branch-point sentence — the neutrinos' decoupling, a TEMPERATURE ordering, flagged as a false positive by the finder in advance — survived the sweep.** **PART 4 AND THE GATE WAS VERIFIED AGAINST A CLEAN TREE, WHICH MEASURES NOTHING:** seeding prop:subhorizon's body back to "at the branch point" left 'check_loci' printing *clean* and exiting 0. *A proposition states its claim in the body and cites its receipt in the argument paragraph below, so the corpus's most load-bearing claim shape was the one shape a per-sentence scan is blind to — and it was the item's own first site.* ⇒ ***Theorem-body binding added; 11→12 bindings, +0 false alarms, motivating defect MISSED before and CAUGHT after.***). *Computes:* **the inversion itself asserted from the metric function — without it the substitution is cosmetic and every edit is unmotivated**; r*/r_seam re-derived to 1.5338 from the quartic rather than quoted; the six repaired strings as-

serted PRESENT and the six defective strings ABSENT, by text so a reintroduction fails this file; **the protected false positive asserted still present — a sweep that also took the one true sentence would be a different error with the same shape**; and **the recall hole asserted in BOTH directions — MISSED before the binder extension, CAUGHT after — so if the pre-extension scan ever starts catching it, this file says the hole was not real**; plus the declared exception asserted to LAPSE when its sentence is rewritten *Bound:* **scope: this is exposition and instrument, not physics — no number in the cosmology moves. Its warrant is 'THE_METHOD' §III: a framework a reader cannot follow cannot be excavated, and this one had a heading contradicting its own proposition. The completeness qualification added at sec:coherence is transcribed from 'C2_horizon_limits' STEP 6, which the paper's sentence contradicted; it is not a new physics claim. 'check_loci' remains a triage lint and not a CI gate — the contributor's call, not reversed here.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_locus_was_wrong_in_six_places_and_the_lint_could_not_see_the_worst`

P15R73 `P15_the_filter_is_a_sound_speed_filter` [OK]
sec:what-crosses (**THE BRANCH-POINT SELECTION RULE'S EXPONENT HAS TWO FACTORS AND THE CORPUS VARIES ONLY ONE.** The damping is e^{-k c_s |Delta eta|}: 'sec:what-crosses' holds c_s at the plasma's value and varies k, reading a SCALE criterion (frozen against oscillating). **Hold k and vary c_s and the same inequality is a SPECIES criterion – and a pressureless component has c_s = 0 IDENTICALLY, so its exponent vanishes at EVERY wavenumber.** ** THAT MAKES THE MATTER SECTOR'S INHERITANCE EXACT RATHER THAN ADIABATIC: ** at c_s = 0 the segment's mode equation is psi" = 0, whose constant solution the kernel leaves untouched with no approximation, whereas the frozen-mode argument rests on horizon exit and degrades at small scales. The two agree wherever both apply; only the pressureless one is available everywhere. COMPUTED on the corpus's own segment: (1) |Delta eta| = 3.3197 (the recorded 3.32); (2) exact transfer-matrix transmission in BOTH k and c_s, reproducing -k c_s |Delta eta| to the digit for every constant c_s; (3) **ln T = 0 EXACTLY at c_s = 0 for k = 1, 10, 85.3, 1e3, 1e5 – uniform in k**; (4) at the first peak the exponent runs ~1.6e2 c_s/c, so the filter is opaque above c_s ~ 3.5e-3. ** CONSEQUENCE: a per-cent sound speed already gives e^-1.6 and ten per cent e^-16, so THE CROSSING CAN INHERIT PERTURBATIONS FROM A COLD SPECIES AND FROM NO OTHER – a sharp condition on what the progenitor may hand over. ** **(SCOPE: the arithmetic is what this receipt establishes; no species selection rule follows from it. The kernel acts on OSCILLATORY content and nothing arrives oscillating ('P16_every_mode_is_frozen_at_the_crossing'), so the exponent computed here has nothing to act on and the crossing is lossless for EVERY species.)**). *Computes:* the segment's conformal length asserted at 3.32; the plasma exponent asserted in (-160,-140); ln T asserted zero to 1e-9 at c_s = 0 across five decades in k *Bound:* ** THIS IS THE FIELD HALF ONLY. ** What happens to perturbations of a given species; the detailed WORLDLINE dynamics of a concrete model at the branch point is a separate computation and is not done. **And an honest bound**: on this segment the plasma exponent comes out -147 against the -152 the corpus records, a 3% difference from the sound-speed profile's discretisation – nothing here turns on it, the load-bearing result being the exact vanishing at c_s = 0, which is profile-independent *Run:* `python3 receipts/P15_CR_cosmology/P15_the_filter_is_a_sound_speed_filter.py`

P15R74 `P15_the_collapse_leg_is_scale_invariant` [OK]
sec:transmission (**THE COLLAPSE LEG IS A SCALE-INVARIANT BACKGROUND, AND P15 LISTS 'CR HAS NO INFLATIONARY SCALE-INVARIANT ATTRACTOR' AS AN ESTABLISHED SIGNATURE. THE ADJECTIVE WAS CARRYING THE SENTENCE.** For a background a ~ (-eta)^beta with z ~ a, the Mukhanov-Sasaki potential is beta(beta-1)/eta^2, so scale invariance requires beta(beta-1) = 2 – **a quadratic with TWO roots: beta = -1, de Sitter inflation (expanding), and beta = +2, a MATTER-DOMINATED CONTRACTION.** **And the corpus's own collapse leg is beta = 2 exactly:** its banked near-branch-point law r^3 = (9/2) M tau^2 with a = |r| gives d ln a/d ln tau = 2/3 and d ln eta/d ln tau = 1/3, hence a ~ eta^2 – forced by f -¿ -2M/r, the mass term dominating and the Lambda term vanishing, **which is the same pressurelessness 'A·4' used at c54.112 to show such a component crosses exactly.** The mode equation integrated from vacuum data on both backgrounds returns d ln P/d ln k = 0 to a part in 10^4. **So n_s = 1 is produced by the construction rather than inherited from the progenitor, and only the DEPARTURE from unity is owed.**). *Computes:* the two roots asserted [-1, 2]; both logarithmic slopes of the leg asserted exactly 2/3 and 1/3; both integrated spectra asserted flat to 1e-3 *Bound:* **bound, and it is the whole caution: this is the STANDARD contraction result (Wands

1999; Finelli-Brandenberger 2002) applied to a background the corpus DERIVES. It inherits that literature's known difficulty – whether the matching across the bounce selects the scale-invariant mode – and here the bounce is a branch point with an analytic continuation rather than a smooth bounce. THAT QUESTION IS NOT SETTLED HERE and is registered as 'L-169'** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_collapse_leg_is_scale_invariant.py`

P15R75 `P15_the_continuation_is_diagonal` [OK]
sec:predictions (**THE CONTINUATION THROUGH THE BRANCH POINT ACTS DIAGONALLY ON THE TWO PERTURBATION MODES, SO THE SCALE-INVARIANT SPECTRUM DOES NOT REACH THE OBSERVER.** The falsifier on the companion result, named at c54.122 and run at c54.123. **The scale-invariant spectrum sits in the mode that DOMINATES the contraction (zeta ˜ etaˆ-3); the mode that SURVIVES on the expanding side is the constant one, whose spectrum from vacuum data is n_s - 1 = 6.** Whether the first reaches the second is a connection problem, settled here two independent ways. **(i) PARITY: the exponents 2 and -1 differ by an integer so a logarithm could mix them – but sinhˆ(2/3) is EVEN in tau, which places its correction at etaˆ6 and steps the Frobenius recursion in SIXES past a resonance sitting at THREE. No logarithm.** **(ii) NUMERICS: continuing both solutions around the branch point, the diagonal entry goes to 1.000131 and the leakage falls as a clean deltaˆ(2/3) power law – and the power law is itself evidence against a log, which would leave a residual no power of delta removes.** So c54.122's scale invariance is confined to the contracting side. **What survives is narrower and sharper than what it replaced: the construction HAS a scale-invariant background, and the obstruction is a PARITY PROPERTY OF ITS OWN SOLUTION rather than a missing mechanism.**). *Computes:* indicial exponents asserted; both vacuum coefficients' k-scalings asserted exactly -3/2 and +3/2; the absence of odd powers in the correction asserted; the resonance asserted unreachable; the diagonal entry asserted to 1e-3 and the leakage ratio asserted equal to 10ˆ(-2/3) at every decade *Bound:* **bound: this settles the connection for the SCALAR mode equation on this background. It does NOT settle what a background correction ODD in tau would do – which is what mixing would require and is the named open route. Three defects were caught in the making: a check that only proved invertibility, a branch error from squaring before taking the cube root, and a test run at delta where k eta ˜ 1.4, outside its own frozen-mode hypothesis** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_continuation_is_diagonal.py`

P15R76 `P15_the_evenness_is_the_time_symmetry` [OK]
sec:predictions (**THE DIAGONALITY IS THE CONSTRUCTION'S TIME-REVERSAL SYMMETRY, AND THE SAME INVARIANCE THAT FIXES THE PEAK HEIGHTS IS WHAT STOPS THE SCALE-INVARIANT SPECTRUM CROSSING.** The falsifier left by the previous receipt – mixing needs a background correction ODD in tau, with the Z_3 monodromy the named candidate – fires NEGATIVE. **Write the law as r = A uˆ(2/3) g(u) with g = [sinh(u)/u]ˆ(2/3): ALL the branch structure sits in uˆ(2/3), and g is EVEN, analytic and non-vanishing at u=0** – exactly, not to a truncation, since log(sinh u/u) is analytic in uˆ2 near 0 and the exponential of a series in uˆ2 is a series in uˆ2. **The three sheets differ by a CONSTANT cube root of unity, and a constant multiplier cannot change a parity, so no sheet has an odd part; the conjugate branch is even too and has no branch point at all.** **AND THE EVENNESS IS r(-tau) = r(tau): the cosmogenesis is TIME-SYMMETRIC about the branch point, and a time-symmetric background cannot mix a growing mode with a decaying one because mixing would distinguish a direction of time the background does not.** P15 sec:amplitude already leans on this same invariance one observable over – the peak HEIGHTS follow from a driving amplitude exactly invariant under time reversal. **One symmetry, two consequences, and the corpus had banked only the welcome one.**). *Computes:* sinh(u)/u asserted even with unit value at 0; g asserted free of odd powers through uˆ12; all three sheets asserted free of odd powers; coshˆ(2/3) asserted even; sinhˆ2 asserted invariant under u -¿ -u *Bound:* **bound: the leg is exactly even because it is the marginally-bound E=1 geodesic of an exactly VACUUM SdS exterior. A progenitor with real matter content – pressure, dissipation, anything carrying an arrow – would not be. This receipt does not exclude that; it LOCATES it, and puts the question back where 'L-150' already sits** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_evenness_is_the_time_symmetry.py`

P15R77 `P15_the_geometry_transmits_no_parameters` [OK]
sec:transmission (**THE INHERITED DATA ARE NOT INHERITED FROM THE COLLAPSE GEOMETRY, BECAUSE THAT GEOMETRY TRANSMITS ZERO PARAMETERS. A COUNT, AND THE CORPUS PROVED THE KEY STEP ITSELF WITHOUT CASHING

IT.** The SdS progenitor family is parametrised by M alone – alpha is the one invariant and E=1 is a choice of geodesic – so the geometry is ONE-dimensional. **And c54.113 showed the Kretschmann along the bead is MASS-FREE in the faller's own proper time (dK/dM = 0, re-asserted here; K -¿ (64/27)/tau^4). A quantity identical for every member carries no information about which member it was, so the approach transmits ZERO parameters, not one.** Against that the corpus draws at least FOUR independent numbers: A_s, n_s, eta, z_onset (= rho_r/rho_m, one datum by c54.105), and the light-element composition. **Four numbers cannot come from zero parameters, so 'inherited from the progenitor collapse' cannot mean inherited from the collapse GEOMETRY – it means inherited from the progenitor's MATTER CONTENT, which M does not carry, the exterior being exactly vacuum and the interior dust without composition.** This RECLASSIFIES the row: not a derivation problem but a modelling one. **What the geometry does fix it fixes universally: |Delta eta| = 3.32 alpha = 1.8e4 Mpc, from Lambda alone – a CUT-OFF, not a CONTENT.**). *Computes:* dK/dM asserted zero and the 64/27 limit asserted; the count of drawn data asserted at least four; the conformal length asserted 3.32 alpha and asserted to land between 1.5e4 and 2.0e4 Mpc *Bound:* **bound: a counting argument about what the construction's own description of the progenitor can carry. It does NOT show that no model supplies eta – it shows no model of the VACUUM EXTERIOR can, and that the row needs an interior** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_geometry_transmits_no_parameters.py`

P15R78 `P15_hbar_survives_in_As_and_cancels_in_ns` [OK]
sec:transmission (**hbar IS A MULTIPLICATIVE CONSTANT IN THE POWER SPECTRUM, SO IT SURVIVES IN THE AMPLITUDE AND CANCELS IN THE TILT — WHICH IS WHY n_s IS DERIVABLE HERE AND A_s IS NOT.** The vacuum normalisation v = sqrt(hbar/2 c_s k) e^{-i c_s k eta} is the only place a quantum constant enters, and zeta = v/z with z classical, so P(k) = hbar A_0 k^(n_s - 1): **A_s = P(k_0) carries hbar, and d ln P/d ln k does not — asserted both ways.** An amplitude is the spectrum at one wavenumber; a tilt is its ratio to itself at two. **So the no-magnitude result (c54.128: neither real form supplies a second scale, and hbar, c, G are unit gauges over the single one) forbids deriving A_s and says nothing about n_s.** A_s is therefore permanently inherited while n_s is not, and the two were never the same kind of quantity — though the corpus has named them together in every statement of the frontier, which is how one got worked for thirteen revisions while the other went unexamined. **AND THE INVERSION LOOKED LIKE THE PAYOFF: a quantity not derivable from the invariants is a function of the moduli, so A_s = F(2M/alpha) and the observed A_s would MEASURE the parent's mass. SUPERSEDED at c54.137 ('P15_the_progenitor_vacuum_is_negligible_too'): F is computed, it is a function of TWO moduli rather than one, and it carries no fixed normalisation — the incoming amplitude is a classical datum, so the relation cannot be inverted. The hbar asymmetry itself stands unchanged.** Second handle on the same object: the spectral bound constrains total expansion past equality, this constrains the mass, and the recollapse condition caps that mass below Nariai.). *Computes:* the hbar-dependence of A_s asserted non-zero and of the tilt asserted zero *Bound:* **bound: F itself is NOT computed. The pieces exist — the mode functions, the monodromy, the mode map — and what is missing is the normalisation carried through all three rather than tracked as a scaling. The settled part stands alone: A_s is not derivable, for a reason, and the reason names which other quantities share its fate — every magnitude, and no ratio** *Run:* `python3 receipts/P15_CR_cosmology/P15_hbar_survives_in_As_and_cancels_in_ns.py`

P15R79 `I11_I1_one_condition_two_jobs_and_the_two_routes_are_independent` [OK]
sec:properframe (I11+I1 — ONE CONDITION, TWO JOBS; AND P09's TWO ROUTES ARE INDEPENDENT. Integrable-systems field bake, probes I11 and I1. E = 1 is k = 0 by -k = E^2 - 1; the sinh^(2/3) law satisfies the marginal equation identically and leaves a residual of exactly +k away from it, so the closed form is the marginal member's alone. The same condition puts V_eff = 1 at M = -r^3/(2 alpha^2), the comoving turnaround at NEGATIVE areal radius – so one condition fixes the rest frame by the field and makes the cosmology integrable. And P09's routes are independent: route (a) grants an additively separable ansatz before deriving from it, route (b) runs on the speciality invariant and contains no separability variable, which is why only (b) answers the prior question.). *Computes:* runs clean; twelve verdicts *Bound:* COMPUTES: alpha = 1 as the scale-invariant gauge, matching the thesis; no physical parameter pinned. Note: M and r are declared UNRESTRICTED, since positive=True silently removes the negative-radius root the probe is about *Run:* `python3 receipts/P15_CR_cosmology/I11_I1_one_condition_two_jobs_and_the_two_routes_are_i`

`Q1_a_stated_tolerance_is_a_request_and_the_corpus_answers_it` [OK] *sec:diffusion-scale* (Q1 — A STATED TOLERANCE IS A REQUEST, NOT A RESULT: RUN THE CORPUS'S ODEs AGAIN AND SEE. Numerical-analysis field bake, probe Q1, and this field's real target is the receipts rather than the prose. Census: 24 receipt files integrate an ODE and ALL 24 set an explicit rtol and atol, not one relying on a solver default; 4 contain any convergence or refinement language. So the corpus states its tolerances and, in twenty of twenty-four files, does not verify them. This receipt does the verification: scipy's solve_ivp is patched to run every call at 100x tighter tolerance, four receipts are re-run unmodified in subprocesses, and EVERY ONE still passes its own assertions. Control: a deliberately under-resolved stiff integration through the same harness DOES move, so the patch applies and the comparator sees. Verdict 5 names the margin on the corpus's one prose-side validation: r_s = 144.0 vs CAMB 144.4 is a 0.28% disagreement against the 8.2% signature it feeds, adequate by a factor of thirty.). *Computes:* runs clean; five verdicts and a control that detects a moved number *Bound:* derived here; a first comparator reported a 92% change that turned out to be a RESIDUAL column, which is supposed to move — the naive test was measuring its own patch, and the honest test is whether the assertions survive *Run:* `python3 receipts/L_numerics/Q1_a_stated_tolerance_is_a_request_and_the_corpus_answers_it.py`

`Q50_the_tolerance_comparisons_gate_the_verdict_and_a_third_of_them_are_not_tolerances` [OK]
sec:diffusion-scale (Q5 asked whether the corpus's 688 (now 1116) 'abs(...) ¡ tol' comparisons carry meaningful tolerances and left it open for want of a mutation harness; the harness is built, and both halves of the answer are here – the comparisons DO gate the verdicts, and a third of them are not accuracy assertions at all). *Computes:* rewrites every site three ways and runs each from the receipt's own directory – margin (semantics-preserving, records E/T), mutate-up (abs(E+3T), catches the assert shape), mutate-down (abs(E)*0, catches the guard shape). Over 269 files and 1116 static sites: the margin transform reproduces the baseline verdict on 269 of 269; of 245 baseline-passing receipts 243 are gated by a tolerance comparison; and of 918 executed sites 210 sit at exactly zero and 54 at or over their tolerance. The receipt asserts the harness's five controls and four invariants live on a ten-file subset holding every verdict class *Bound:* SUPPORTS P15 – and closes Q5 as a CONFIRMATION, as Q1 closed. NOT CLAIMED: that any particular tolerance is the right one; this measures whether a comparison gates the verdict and how much room it has, not whether its author chose well. The two ungated files are a display filter and a documented skip that names its gated substitute *Run:* `python3 receipts/L_numerics/Q50_the_tolerance_comparisons_gate_the_verdict_and_a_third_of_them_are_not_tole`

P15R80 `P15_the_progenitor_vacuum_is_negligible_too` [OK]
sec:amplitude (**THE PROGENITOR'S OWN VACUUM, CARRIED THROUGH THE FULL PASSAGE AND AMPLIFIED BY THE BRANCH-POINT MIXING, IS ALSO NEGLIGIBLE — SHORT BY 1e104. So 'prop:amplitude' had ruled out the one vacuum the inheritance story was NOT claiming.** The collapse-side background is a single function, a = M(rho x + x^2/2) with x = |eta - eta_c|, whose Mukhanov-Sasaki potential 2/(x(x+2 rho)) is **M-FREE**, so the mass enters only through the final division zeta = v/a. The passage has three stages and each contributes one factor of 1/rho: (i) the mode freezes on the beta = 2 leg as v -¿ D_k/x with D_k = sqrt(hbar/2) k^(-3/2); (ii) **the connection through equality is elementary — v = a int dx/a^2 solves the k = 0 problem exactly and carries D_k/x to the constant (3/2 rho)D_k**; (iii) the crunch monodromy leaks it into the survivor with coefficient 2 pi/rho; and a'(eta_c) = -M rho supplies the third. **THE TRANSFER LAW IS THEREFORE P = 18 k^3 D_k^2/(M^2 rho^6), with the k^3 cancelling identically on vacuum data — exactly scale-invariant.** On the vacuum that is A_s = (9/4)(l_P/M)^2 rho^(-6) = 2e-113 at the recollapse cap and the determined rho, against an observed 2.1e-9. **The mixing buys eight orders over the bare vacuum and is still short by a hundred and four.** Two corollaries: A_s does NOT measure the progenitor's mass, D_k being free; and the classical datum has a size — the parent's growing-mode amplitude exceeded its own vacuum's by ~1e47. **The same closed form also returns c54.131's monodromy analytically, the (x/rho)ln x term continuing to -2 pi i/rho, where it had been obtained by numerical continuation.**). *Computes:* the M-free potential asserted symbolically; the connection coefficient asserted in closed form and against integration from vacuum data to 0.10% over a decade in rho and a factor 15 in k; the transfer law asserted k-independent; the shortfall asserted between 1e101 and 1e106 *Bound:* **bound: z = a with c_s = 1 is assumed on the beta = 2 leg — c54.122's own hypothesis and the standard matter-contraction idealisation, genuine dust having c_s = 0 and no vacuum oscillation to normalise. The 1e104 is far too large for any O(1) convention or plausible c_s treatment to touch** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_progenitor_vacuum_is_negligible_too.py`

P15R81 `P15_no_primordial_B_modes_unconditionally` [OK]
sec:amplitude (**THE TENSOR SECTOR IS WHERE THE COLLAPSE-TRANSFER MACHINE RUNS WITH NO IDEALISATION AT ALL, AND IT RETURNS P_T ˜ 5e-111 — ONE HUNDRED ORDERS BELOW THE OBSERVATIONAL CEILING.** The scalar transfer needs z ˜ a, which for a fluid holds only where w and c_s are constant — and across the progenitor's own equality (1+w) runs 1 -¿ 4/3 while c_s runs 0 -¿ 1/sqrt3, so neither is. **For tensors that is not a restriction: z_T = a M_Pl/2 EXACTLY, for any content, any equation of state, any sound speed, so z_T"/z_T = a"/a identically and the entire passage — background, connection (3/2 rho), monodromy (2 pi/rho), division by a'(eta_c) = -M rho — applies verbatim with nothing assumed.** It returns **P_T = 144 pi (l_P/M)^2 rho^(-6), scale-invariant (k cancels identically)**, i.e. 4.8e-111 at the recollapse cap and the determined composition, against a ceiling of 6.7e-11 from r ¡ 0.032: **below it by 1.4e100, so r = 2e-102.** So the absence of primordial B-modes is a prediction at any conceivable sensitivity, and **it no longer rests on the substrate's own tensor floor — that argument had the same scope defect its scalar twin did, ruling out the substrate's vacuum and saying nothing about the progenitor's.** And the ratio is fixed too: every k-dependent factor is shared by the two sectors, so **r_out = 6 r_in (c54.146: scalars mix twice as strongly as tensors), k-independently — the crossing can neither manufacture nor destroy a tensor signal, only rescale the ratio.** The observed bound therefore measures the PARENT: its own tensor-to-scalar ratio was below 1.3e-3.). *Computes:* P_T asserted k-independent and asserted equal to 144 pi (l_P/M)^2 rho^(-6) symbolically; the shortfall against the ceiling asserted above 1e95; the crossing ratio asserted equal to 24 *Bound:* **bound: the factor 24 carries the scalar side's idealisation (it is 24(1+w)c_s on the contracting leg, the standard matter-bounce value) and no more. The absolute P_T carries nothing** *Run:* `python3 receipts/P15_CR_cosmology/P15_no_primordial_B_modes_unconditionally.py`

`A2_the_three_owed_derivations_are_one_boundary` [OK]
sec:scope (the three owed derivations are ONE closed boundary: A_s, n_s and the inherited datum are all dimensionless magnitudes). *Computes:* asserts P15s own list, prop:amplitudes 10^113 gap, the progenitor tilt, and the capstones derived progenitor composition (13 checks) *Bound:* NOT-A-PAPER-CLAIM — L-211 run on L-150 *Run:* `python3 receipts/L211_closure_adjacency/A2_the_three_owed_d`

P15R82 `P15_the_control_entered_the_regime_and_the_arm_did_not_move` [OK]
sec:refit-bound (**THE WAVENUMBER TRUNCATION WAS 78% OF THE CONTROL'S REMAINING chi^2, AND REMOVING IT TAKES THE CONTROL TO chi^2/dof = 1.18 OVER THE FULL RANGE AGAINST A TRUE LambdaCDM FIT'S 1.01 – SO FRONT #2's TARGET IS MET. ACROSS FOUR INSTRUMENT STATES THE CR ARM DID NOT MOVE, AND 'L-147''s PRE-REGISTERED F4 FIRES.** Front #2, lead 'L-500'. **PART 1 WHERE THE RESIDUAL LIVES.** Of the 989 surviving c54.183's derived lensing, **725 – 73% – is in the 30 bins above ell = 1500, a sixth of the bins**; below ell = 700 the control is at chi^2/dof = 0.85 against CAMB's lensed LambdaCDM at 0.82 on the same bins. **PART 2 AND IT IS THE TRUNCATION, SHOWN BY REMOVING IT RATHER THAN BY ARGUING FOR IT.** The grid is k = ell/D_M with ell ¡= LMAXL, so the top output multipole has NO k-headroom while C_ell draws on every k with k·D_M ¿= ell. **Re-run at LMAXL = 3000 with the k-spacing held fixed and scored on the SAME 185 bins: 989 -¿ 218, chi^2/dof 5.34 -¿ 1.18, and the last band's ratio to the reference 0.42 -¿ 0.99.** *So c54.184's '53% in neither template set' was the truncation; the front's last named item is struck as NUMERICAL and no sector remains.* **PART 3 THE CR LADDER'S ALIAS-GATE WAIVER, CHECKED IN chi^2 FOR THE FIRST TIME.** The gate demands 4 samples per Bessel period, the CR ladder has 2.3, and it waives itself with *'this is not aliasing – but it is only not aliasing if the answer does not depend on it. Run KCONT=1 to check.'* **Run: agreement better than 0.7% everywhere, chi^2 to 2.1 in 51817.** *That check existed for the PEAK POSITION and had never been run against the statistic the verdict reads.* **PART 4 FOUR INSTRUMENT STATES, full range, both arms on the same lensing operator: the control 21.2 -¿ 27.7 -¿ 5.34 -¿ 1.18 and the CR arm 290.7 -¿ 304.2 -¿ 298.9 -¿ 302.1.** *An error the INSTRUMENT carries moves both arms; this moved one – eighteenfold against 5%.* **PART 5 F2 AND F3 AS 'L-147' DEFINES THEM, WITH BOTH ARMS AT THE SAME WAVENUMBER RANGE** so the construction is not charged for the instrument's truncation. Full range **F2 = 31 and F3 = 51848**; below ell = 700 **F2 = 3.8 and F3 = 23687**; below ell = 500 F2 = −0.2, the arm scoring no worse than the reference. **F4's second clause fires by three orders of magnitude where it asks for one.**). *Computes:* the k-adequate control at full range asserted at 1.18 +- 0.12, **without which there is no discriminating regime and nothing in the

file may be read**; the share the truncation carried asserted above 60%, which is PART 2's whole mechanism; F3/F2 asserted above 100 at full range AND below ell = 700, which IS the reopening; **the ladder/continuum agreement asserted under 2%, without which the CR arm's chiˆ2 is not admissible at all**; the continuum arm asserted at l_1/l_A = 0.5703; the four-state contrast asserted as a ¿5x control improvement against a ¡15% arm movement, which is what makes this a statement about physics rather than about one build; and the tail share asserted above 60%, since PART 1 is what sent PART 2 looking *Bound:* **scope: this is a MEASUREMENT DISCREPANCY and NOT a framework verdict – 'L-147''s own F5 says so and 'PO-7' is protected precisely here, so this file reports a number and does not convert it; the conversion runs by 'F5''s stated procedure. The deficit itself is not new: the corpus has carried l_1/l_A = 0.5703 against the sky's 0.7312 since c54.168 and P15 states it at 21.9%. What is new is a control good enough to read it through a likelihood instead of a ratio. AND WHAT IS NOT RULED OUT: a defect the instrument's states SHARE – 0.5703 has not moved across EIGHT of them, which is evidence either of a robust prediction or of a shared upstream constant, and this file cannot separate those and does not claim to. Nor does chiˆ2/dof = 1.18 make the control a FIT: it is 17% above a true LambdaCDM's on the same bins, and what that residual is remains unnamed.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_control_entered_the_regime_and_the_arm_did_not_move.py`

`B1_the_control_separates_prediction_from_shared_constant` [OK]
sec:refit-bound (the control separates robust prediction from shared upstream constant: same code, different D_M and r_s, same l_A, peaks 21.8% apart, and the control lands on the sky to 0.17%). *Computes:* reads both arms from the c54.186 spectra and asserts the scaling test, the control agreement and the ladder/continuum equality (12 checks) *Bound:* NOT-A-PAPER-CLAIM — the adversarial check c54.186 requested *Run:* `python3 receipts/L147_two_arm/B1_the_control_separates_predictio`

`B2_the_prose_duplicate_did_not_reach_main` [OK]
sec:refit-bound (the reported prose duplicate did not reach main: zero at three granularities across every commit, because the two edits were different paraphrases and git asked). *Computes:* scans every commit that touched the file at paragraph, sentence and line-window level and asserts the two diffs differ (14 checks) *Bound:* NOT-A-PAPER-CLAIM — checks a routed report before acting on it *Run:* `python3 receipts/L147_two_arm/B2_the_prose_duplicate_did_not_reach_main.py`

P15R83 `P15_the_first_peak_is_the_seam_datum_and_the_spacing_is_not` [OK]
sec:coherence (**ell_1/ell_A = 0.5703 IS A STATEMENT ABOUT THE SEAM DATUM AND NOT ABOUT THE RATE, AND c54.186's OWN CAVEAT IS WHAT SENT THIS LOOKING.** Front #2, lead 'L-501'. The CR arm begins at the seam (z = 6761, eta_S = 180.4 Mpc) and a first-peak mode crossed the horizon at eta ˜ 75, so **the modes that set ell_1 are ALREADY SUB-HORIZON at the start and their phase there is ASSIGNED rather than derived**. The corpus's datum is *'ONE datum per mode and a COMMON phase'* – which fixes that the phase is common and not WHICH phase; the instrument picks a density extremum. **PART 1 SCANNING THAT ONE FREEDOM MOVES ell_1/ell_A FROM 0.5703 TO 1.2599 – A FACTOR OF 2.21**, and at phi = 3pi/8 the peak at 172 is not there at all and the series starts at 380. **PART 2 WHAT IS ROBUST IS THE SPACING, AND IT IS ROBUSTLY WRONG:** the mean peak spacing holds at 0.734-0.818 of ell_A across the whole scan – a spread of 1.11 against the position's 2.21 – and is **never 1.0**. *So the disagreement that does not depend on a choice is a ˜21% SPACING deficit, not a 22% POSITION one.* **PART 3 AND 'L-147''s F4 FIRES UNDER EVERY PHASE, WHICH IS WHY c54.186 SURVIVES THIS:** on identical bins the CR arm runs chiˆ2/dof 202-449 against a control at 0.75, so **even its BEST phase costs 269x the control**. **PART 4 THIS REPRODUCES c54.164 ON THE CURRENT INSTRUMENT, WHICH HAD NOT BEEN DONE** – that revision found ell_1 in {150, 165, 315} on the OLD 'ROBUST_p1p2_scan' code, and the finding was never carried across to 'ACOUSTIC_two_arm', which everything since is built on.). *Computes:* **CRPHI = 0 asserted to reproduce the coded 0.5703, without which the knob is not a control on itself and every comparison is against the wrong baseline**; the position's spread asserted above 1.5x and its maximum pinned at 1.2599, which is the withdrawal; the spacing's spread asserted under 1.35x AND its maximum under 0.95 of ell_A, **since if the spacing ever moved this file would have no positive content**; and the CR arm's BEST phase asserted above 50x the control and above chiˆ2/dof 150 – **if that ever falls, c54.186 must be RESTATED rather than defended** *Bound:* **!! SUPERSEDED BY P15_the_spacing_is_right_and_the_acoustic_phase_is_wrong (r4401).** *Headline claim withdrawn by a later revision of 'sec:refit-bound'; the only citation available would put back into the paper

what the paper removed — attempted r4397, reverted r4399. **Kept, not deleted: the scans stand and this is the record of how the arc reached its present state.*** **scope: this WEAKENS a number the paper carries and STRENGTHENS a verdict the previous revision landed, and neither is a framework judgement. P15's '21.9% deficit, not an artefact of how last scattering was modelled' is TRUE and is not the sentence a reader takes from it: the deficit is not last scattering's, it IS a function of the seam phase, which is upstream of last scattering and is a choice inside the corpus's own stated datum. 'F5' is not softened – removing a confound makes a measurement cleaner, not a conclusion; 'PO-7' protected; the conversion runs by 'F5''s stated procedure. AND WHAT IS STILL OPEN, narrower than before: the phase is ONE degree of freedom in the datum; Theta-hat's flatness in k is another and is NOT scanned here. A scan that moved the SPACING would be the one that mattered, and this file does not run it.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_first_peak_is_the_seam_datum_and_the_spacing_is_not.py`

`B3_a_dichotomy_stated_is_not_a_dichotomy_proved` [OK]
sec:refit-bound (B1 stands but L-235s disposition did not follow: ruling out one horn establishes the other only if the dichotomy is exhaustive, and the truth was a third thing). *Computes:* reads the forks nine phase spectra and asserts the 2.21x position spread against the 1.11x spacing spread (12 checks) *Bound:* NOT-A-PAPER-CLAIM — corrects this lines own r2462 disposition *Run:* `python3 receipts/L147_two_arm/B3_a_dichotomy_stated_is_not_a_dichotomy_proved.py`

P15R84 `P15_both_datum_freedoms_opened_and_the_spacing_still_holds` [OK]
sec:coherence (**THE SECOND AND LAST FREEDOM IN THE SEAM DATUM IS OPENED, AND THIS FILE WIDENS ITS OWN PREDECESSOR RATHER THAN CONFIRMING IT.** Front #2, lead 'L-502'. c54.187 scanned the common PHASE and named the other freedom: what "flat in k" is flat AT. The datum's amplitude is the corpus's C4 shape $T(x) = 3(\sin x - x\cos x)/x^3$; **the instrument evaluates it at a SINGLE argument xe = 1/sqrt(3), which is that shape read at each mode's OWN horizon crossing** (x = k c_s eta with k·eta = 1 gives exactly 1/sqrt(3)) — a self-similar reading. *The alternative evaluates the SAME shape at each mode's own phase AT THE SEAM, x = k c_s eta_S.* Both are readings of "one datum per mode"; neither is a new assumption. **PART 1 THE POSITION IS NO MORE STABLE:** across eighteen readings ell_1/ell_A spans **0.5570–1.2599, 2.26x** against the phase scan's 2.21x. **PART 2 THE SPACING IS MEASURED ONLY WHERE THERE IS A SERIES TO MEASURE, WHICH DISQUALIFIES EIGHT OF THE EIGHTEEN:** those return a spectrum whose higher peaks have COLLAPSED — three features, the last at zero — and *a spacing read off that is not a spacing*. Requirement stated before the numbers: four peaks, the fourth at least 5% of the first. **PART 3 OVER THE TEN THAT QUALIFY THE SPACING SPANS 0.6764–0.8179 OF ell_A — 1.21x, mean 0.772, never above 0.82.** ***c54.187 reported 1.11x from the phase alone; opening the second freedom widens it to 1.21x, so this file weakens its own predecessor and the ˜23% spacing deficit stands at LOWER strength.*** **PART 4 AND F4 FIRES AT EVERY ONE OF THE EIGHTEEN:** chiˆ2/dof runs 157–460 against a control at 0.75 on identical bins, so **the arm's best reading costs 208x the control**. *And the best-fitting reading is one of the eight DISQUALIFIED ones — it fits better by having less structure to disagree with. Reported because it is the best number in the table and a reader would find it; it is not a direction.*). *Computes:* the position's spread asserted above 1.5x with its maximum pinned at 1.2599, the standing withdrawal from c54.187; **the spacing's spread asserted under 1.6x AND its maximum under 0.90 of ell_A — the point past which c54.187's conclusion would have to be WITHDRAWN rather than widened**; the usable-series count pinned at 10, since PART 3's range is computed only over those and a silent change in how many qualify would move it without moving the code; and **the arm's BEST reading asserted above 50x the control and above chiˆ2/dof 120 — if that falls, c54.186 is restated** *Bound:* **!! SUPERSEDED BY P15_the_spacing_is_right_and_the_acoustic_phase_is_wrong (r4401).** *Headline claim withdrawn by a later revision of 'sec:refit-bound'; the only citation available would put back into the paper what the paper removed — attempted r4397, reverted r4399. **Kept, not deleted: the scans stand and this is the record of how the arc reached its present state.*** **scope: both freedoms the corpus's own phrase leaves open are now scanned and the datum is closed. What has NOT been varied is the background: 'Z_START' is solved so that pi·D_M/r_s = 301.6 exactly, which is a TARGET and not an output — a separate item from the datum, registered rather than resolved. 'F5' unsoftened, 'PO-7' protected, conversion Daryl's.** *Run:* `python3 receipts/P15_CR_cosmology/P15_both_datum_freedoms_opened_and_the_spacing_still_holds.py`

P15R85 `P15_the_floor_is_a_distance_between_models_not_a_number_from_the_data` [OK] *sec:refit-bound* (**THE CONTROL'S REMAINING 17% IS NAMED, AND NAMING IT REQUIRED CHANGING THE MEASUREMENT.** Front #2, lead 'L-503'. c54.186 left it unnamed; **'F2' as 'L-147' defines it is a difference of two numbers each computed AGAINST THE SKY, so it mixes how far the two models are apart with where each sits relative to one noise realisation.** **PART 1** amplitude-matched, the instrument tracks a reference LambdaCDM to **better than 1.6% everywhere**, the departure running −1.1% at ell ~ 200 through zero near 600 to +0.7% at 1400 — *a slow undulation, not a mis-phased oscillation*. **PART 2 F2 IS NOT A CLEAN MEASURE, SHOWN BY MOVING THE REFERENCE:** three defensible LambdaCDMs give **+31.2, +21.5, +27.2** — *a spread comparable to the value*. **PART 3 SO THE FLOOR IS MEASURED WITHOUT THE DATA** — chi2_sep = (A_a m_a − A_c m_c)^T F (A_a m_a − A_c m_c), a distance between two MODELS: **21.3 over 185 bins, 0.11 chi^2 per bin, about a third of a standard deviation per bin**. **PART 4 AND THE ORDERING REVERSES, WHICH IS THE TRAP:** the massless-neutrino reference gives the **smallest F2 (21.5) and the largest separation (62.7)** — *a reference chosen to flatter the instrument through the data is the one it is furthest from as a model*. **AND c54.178's LIST IS NOW COMPLETE:** reionisation struck c54.181, lensing built c54.183, the wavenumber range closed c54.186, and **the neutrino mass — the one item never addressed — is worth about 10 of the 31**, the reference carrying one massive species at 0.06 eV where this instrument carries none.). *Computes:* the instrument-vs-reference departure asserted under 3%, which bounds everything else; the model separation asserted under 0.5 chi^2 per bin, the number that replaces the unnamed 17%; **THE ORDERING REVERSAL asserted directly — if F2 and chi2_sep ever stop disagreeing, PART 4 is not a trap and the paragraph is unearned**; and **F4's margin asserted above 100x at the WORST reference, since a verdict that depends on the choice is not one** *Bound:* **scope: 0.11 chi^2 per bin is NOT zero and this file does not say the instrument is exact. It says the residual is at the level where the REFERENCE's own parameter choices matter as much as the instrument's error, and that below that level this statistic cannot arbitrate between two LambdaCDM implementations at all. F3 = 51848 against a floor of 21–63 across every defensible reference, so 'F4''s margin is three orders of magnitude whichever is taken — which makes 'L-147''s reading SAFER and converts nothing. 'F5' unsoftened, 'PO-7' protected.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_floor_is_a_distance_between_models_not_a_number_from_the_data.py`

`J1_the_disagreement_no_longer_has_two_sides` [OK]
sec:flatlcdm (L-171s internal disagreement no longer has two sides: across 18 datum readings the perturbation route gives no definite first peak, and its 150 is c54.164s number from a retired instrument). *Computes:* reads every c54.187-188 spectrum, asserts 150 and 220 both absent and the 2.26x range, and ties it to the class c54.187 routed as item 35 (12 checks) *Bound:* NOT-A-PAPER-CLAIM — supersedes a register rows content; its next step is untouched *Run:* `python3 receipts/L171_two_routes/J1_the_disagreement_no_longer_has_two_sides.py`

P15R86 `P15_the_spacing_deficit_survives_the_one_fitted_parameter` [OK]
sec:tensions (**THE LAST FREE THING UPSTREAM IS THE CORPUS'S OWN ONE FITTED NUMBER, AND MOVING IT BY 31% MOVES THE SPACING DEFICIT BY 7%.** Front #2, lead 'L-504'. c54.188 closed both seam-datum freedoms and named this: **'Z_START' is solved so that l_A = pi·D_M/r_s hits a TARGET rather than coming out as an output.** *That is declared, not hidden — P15 sec:tensions says "the measured acoustic scale is reproduced at the directly measured H_0 by a single z_onset" and calls it **"the one fitted number"**. What had not happened is that the number was a literal buried in a 'brentq' call, so nothing downstream could vary it and nothing had.* **PART 1 MOVING THE PIN MOVES EVERYTHING IT SHOULD:** pinning l_A at 260/280/301.6/320/340 drives **z_onset from 11009 to 5066 and r_s from 157.1 to 120.2 Mpc**. **PART 2 AND THE SPACING DEFICIT DOES NOT FOLLOW IT:** the mean peak spacing stays at **0.7647–0.8205 of l_A — a spread of 1.07 against the pin's 1.31, mean 0.798**. *So the ~20% spacing deficit is a property of the construction and not of the value its one fitted parameter was fitted to.* **PART 3** l_1/l_A runs 0.5176–0.6308 (1.22x) and **never approaches the sky's 0.7312** — and its drift is almost entirely l_A's, the peak itself moving only 164 -¿ 176 while l_A moves 260 -¿ 340. **PART 4 THE STRUCTURAL STATEMENT UNDER IT:** in ordinary acoustics l_1 goes as D_M/r_s, so a 24% fall in r_s should raise l_1 by 31%; **here it raises it by 7%**. ⇒ ***This construction's peaks track its own sound horizon at 24% of the rate acoustics requires, and that — rather than any one ratio — is what the comparison with the sky is registering.*** ***CORRECTED c54.190 ('L-505'): the spacing

figure in this row is the mean of the FIRST THREE GAPS, which is all four peaks at LMAXL = 1000 can give. At production depth the asymptotic spacing is 0.975 of l_A — 2.5% short, not 21% — and what is wrong is the ACOUSTIC PHASE, by 0.62 pi. The robustness this row measures stands; the name it gives the quantity does not.***). *Computes:* **the spacing's spread under the pin asserted below 1.20x — the point past which the deficit would BE the fitted parameter's and every conclusion resting on it withdrawn**; its maximum asserted below 0.90 of l_A, since a pin taking it near 1.0 would remove the deficit itself; the first-peak position asserted never to reach the sky's ratio at any pin, which is PART 3; **the peaks' sensitivity to r_s asserted in (0, 0.6) of the acoustic rate — if it ever reached that rate the disagreement would be about a NUMBER and not about a mechanism**; and all five pins asserted to give a four-peak series *Bound:* **!! SUPERSEDED BY P15_the_spacing_is_right_and_the_acoustic_phase_is_wrong (r4401).** *Headline claim withdrawn by a later revision of 'sec:refit-bound'; the only citation available would put back into the paper what the paper removed — attempted r4397, reverted r4399. **Kept, not deleted: the scans stand and this is the record of how the arc reached its present state.*** **scope: the acoustic question on this front is now closed as far as the construction's FREEDOMS go — c54.187 scanned the seam phase, c54.188 the amplitude reading, this the fitted parameter, and across all of them the SPACING sits near 0.78–0.80 of l_A and never reaches 0.9 while the POSITION spans 2.26x and states nothing. What is left is not a freedom that can be scanned: whether the peaks SHOULD be tied to the sound horizon is a question about the physics. 'F5' unsoftened, 'PO-7' protected, conversion Daryl's. AND ONE INCONSISTENCY RECORDED RATHER THAN FIXED: the instrument pins l_A = 301.6 where 'P15_zonset_determinations' pins the MEASURED 301.76 — 0.05%, and it is why this instrument returns z_onset = 6761 where that receipt returns 6797. Named so the two are not read as a disagreement.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_spacing_deficit_survives_the_one_fitted_parameter.py`

P15R87 `P15_the_spacing_is_right_and_the_acoustic_phase_is_wrong` [OK]
sec:refit-bound (**THE "~21% SPACING DEFICIT" OF c54.187-189 IS THE FIRST THREE GAPS AND NOT THE SPACING. AT PRODUCTION DEPTH THE ASYMPTOTIC SPACING IS RIGHT TO 2.4% AND WHAT IS WRONG IS THE ACOUSTIC PHASE.** Front #2, lead 'L-505'. ***THIS FILE CORRECTS THREE OF ITS OWN LINE'S REVISIONS.*** *Those scans ran at LMAXL = 1000 so that eighteen readings and five pins were affordable; at that depth the CR arm has four peaks, so "the mean peak spacing" was a mean of THREE GAPS — and the first three gaps are the only ones where the arms disagree.* **PART 1/2 AT PRODUCTION DEPTH BOTH ARMS CARRY EIGHT PEAKS:** LambdaCDM's last four gaps average **1.002 of l_A** and the CR arm's **0.975 — 2.5% short, not 21%**; gap by gap the CR arm runs **0.725, 0.853, 0.875** of the control's and is **level by the fourth (0.973)**. **PART 3 SO THE TWO SERIES ARE PARALLEL LINES WITH DIFFERENT INTERCEPTS, AND THAT IS A PHASE:** fitted on peaks 4–8, slopes **1.003 and 0.976 of l_A** (agreeing to 2.6%) and intercepts **−0.263 and −0.878 of l_A**. *A driven series peaks at k·r_s = n·pi − phi, so the intercept IS −(phi/pi)·l_A:* ⇒ ***the two differ by 0.62 pi in the ACOUSTIC PHASE SHIFT, at a spacing they agree on.*** **PART 4 AND A LOW-ell TRANSIENT THE CONTROL DOES NOT HAVE:** measured each against its OWN asymptotic line, the control's first three peaks sit within **16** of it and the CR arm's sit **+142, +80, +18**, converging — *and that transient is what compressed the early gaps*. ***PART-HEADLINE CORRECTED c54.195 ('L-508'): the 0.62 pi is the value at phi = 0. Across four seam phases at production depth the asymptotic phase spans 0.891 and the CONTROL'S VALUE LIES INSIDE that span, so it is not a prediction. The driving ATTRIBUTION stands; its promotion to "the whole disagreement" does not.***). *Computes:* **the CR asymptotic spacing asserted above 0.90 of l_A and pinned at 0.975 — if it were NOT near l_A there would be nothing to correct and c54.187-189 would stand as written**; the first-three-gap and asymptotic values asserted to STRADDLE 0.85, which IS the diagnosis (one number reported for the other); **the slopes asserted parallel to 6%, without which the offset is not a pure phase and PART 3 is wrong**; the phase offset pinned at 0.615 +- 0.08, which is what replaces the retracted number; the transient asserted at more than 3x the control's, since PART 4 is otherwise empty; and the weakest peak's contrast asserted above 1.05, since a series read off non-features is noise *Bound:* **!! SUPERSEDED BY P15_two_arm_control_and_guard (r4401).** *Headline claim withdrawn by a later revision of 'sec:refit-bound'; the only citation available would put back into the paper what the paper removed — attempted r4397, reverted r4399. **Kept, not deleted: the scans stand and this is the record of how the arc reached its present state.*** **scope: WHAT THIS RETRACTS is this line's own —

c54.187's "~21%", c54.188's "~23%", c54.189's "~20%" and the paper's "acoustic series some 23% too close" are all the first-three-gap value. WHAT IT DOES NOT RETRACT is the robustness: the first-three-gap spacing IS stable at 0.77–0.82 across eighteen datum readings and five pins and F4 fires at every one; what changes is that the stable quantity was the wrong one to call the disagreement. AND THE CORRECTION MAKES c54.187 CENTRAL rather than a caveat — the disagreement is a PHASE, and the phase is exactly what the seam datum assigns and what "one datum per mode and a COMMON phase" does not fix. 'F5' unsoftened; 'PO-7' protected; the conversion runs by 'F5''s stated procedure — and this makes the discrepancy SHARPER, not smaller: a spacing that is right and a phase that is wrong names where to look.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_spacing_is_right_and_the_acoustic_phase_is_wrong.py`

`B4_the_intercept_is_a_phase_and_the_control_proves_it` [OK]
sec:coherence (the intercept IS the acoustic phase by change of variables, and the control validates the reading by reproducing the textbook 0.25-0.27; the 21% spacing figure was a depth artefact). *Computes:* derives the intercept identity, fits both arms on peaks 4-8, reproduces the gap-by-gap series and the low-l transient (14 checks) *Bound:* NOT-A-PAPER-CLAIM — the adversarial check c54.190 requested *Run:* `python3 receipts/L147_two_arm/B4_the_intercept_is_a_phase_and_the_control_prov`

`B5_the_scan_cannot_test_the_asymptotic_phase` [OK]
sec:coherence (the corrected claims load-bearing quantity cannot be tested by the datum scan: all 23 scan spectra stop at three or four peaks and zero reach the peaks-4-to-8 fit). *Computes:* asserts the depth and peak count of every scan spectrum, that the production pair alone supports the fit, and where the transient sits (11 checks) *Bound:* NOT-A-PAPER-CLAIM — names a small affordable experiment *Run:* `python3 receipts/L147_two_arm/B5_the_scan_cannot_test_the_asymptotic_phase.py`

P15R88 `P15_the_acoustics_work_and_the_phase_is_the_whole_disagreement` [OK]
sec:refit-bound (**THE ASYMPTOTIC SPACING TRACKS THE SOUND HORIZON AT 98% OF THE ACOUSTIC RATE, SO THIS CONSTRUCTION'S ACOUSTICS WORK — AND THE WHOLE DISAGREEMENT IS THE ACOUSTIC PHASE.** Front #2, lead 'L-506'. c54.190 separated spacing from phase and owed both a production-depth test; **the scans that varied them were all at the depth c54.190 showed to be insufficient**. **PART 1 THE SPACING TRACKS r_s AT THE FULL RATE:** moving the pin from l_A = 301.6 to 340 drops r_s by 11%, ordinary acoustics requires the spacing to rise 13%, and **it rises 13% — 98%**. *So the peaks in this construction ARE set by its own sound horizon.* **PART 2 WHICH RETRACTS c54.189's HEADLINE:** that revision reported *"the peaks track their own sound horizon at 24% of the rate acoustics requires"* — **measured on the FIRST peak, which c54.190 showed sits 142 multipoles off the asymptotic line, inside a transient**. *Over this file's pin range the first peak moves at 37% against the series' 98%; the figure is not reproduced and is not meant to be — what is reproduced is the FINDING.* **PART 3 THE PHASE IS ROBUST TO THE FITTED PARAMETER:** the intercept moves $-0.878 \rightarrow -0.899$ of l_A across the same 31% swing — **3% of a discrepancy of 0.62**. **PART 4 AND THE SEAM DATUM'S PHASE FREEDOM IS A REAL LEVER THAT SPANS A THIRD OF IT:** at the opposite phase the intercept moves to -0.671, closing the gap from 0.615 to 0.408 — **34%, and no further**. ⇒ ***Which is the confirmation c54.190's diagnosis wanted: the datum's phase controls the acoustic phase, as a phase diagnosis predicts, and cannot close the gap.*** ***PART-HEADLINE CORRECTED c54.195 ('L-508'): the 0.62 pi is the value at phi = 0. Across four seam phases at production depth the asymptotic phase spans 0.891 and the CONTROL'S VALUE LIES INSIDE that span, so it is not a prediction. The driving ATTRIBUTION stands; its promotion to "the whole disagreement" does not.***). *Computes:* **the asymptotic sensitivity to r_s asserted in (0.85, 1.15) — if it were NOT near 1 the acoustics would not work and the phase reading would not be the whole story**; the FIRST peak's sensitivity asserted below 0.6, since PART 2 retracts a number and must show the quantity really is less sensitive; the pin's effect on the phase asserted below 15% of the discrepancy, without which the phase is the fitted parameter's; **the seam phase's closure asserted in (0.15, 0.70) — if it ever closed the WHOLE gap the discrepancy would be the datum's alone and this front's verdict would have to be restated**; the phase discrepancy pinned at 0.615 +- 0.05; and at least seven peaks per arm, since every number here is an asymptotic fit *Bound:* **!! SUPERSEDED BY P15_two_arm_control_and_guard (r4401).** *Headline claim withdrawn by a later revision of 'sec:refit-bound'; the only citation available would put back into the paper what the paper removed — attempted r4397, reverted r4399. **Kept, not deleted: the scans stand and this is the record of how the arc reached its present state.*** **scope:

the front's acoustic statement in final form — this construction reproduces the acoustic SPACING (the quantity its one fitted parameter is fitted to, and which it then tracks at 98% of the acoustic rate when that parameter is moved) and disagrees with the sky in the acoustic PHASE by 0.62 pi, robust to the fitted parameter and only a third reachable by the one freedom the seam datum leaves open. That is ONE number and ONE mechanism where the front began with four items and a ratio. 'F5' unsoftened, 'PO-7' protected, conversion Daryl's — and the discrepancy is now specific enough to be attacked: an acoustic phase shift is a computable consequence of the driving, so "why 0.62 pi" has an address. This file does not have it.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_acoustics_work_and_the_phase_is_the_whole_disagreement.py`

`B6_the_acoustics_reproduce_and_my_dichotomy_was_false` [OK]
sec:coherence (the acoustics reproduce at 98.2% of the required rate, and r2485s stated dichotomy was not exhaustive: the phase moves and stops at 34%). *Computes:* recomputes the r_s response and the four-row phase table from the forks spectra, and asserts both horns false (13 checks) *Bound:* NOT-A-PAPER-CLAIM — verifies c54.191 and corrects this lines own r2485 *Run:* `python3 receipts/L147_two_arm/B6_the_acoustics_reproduce_and_my_dichotomy_was_false.py`

`B7_the_seam_phase_moves_the_asymptotic_intercept` [OK]
sec:coherence (item 38 answered at production depth: the seam phase MOVES the asymptotic intercept by ~0.31 lA (half the 0.615 disagreement) while the spacing holds, so the 0.62pi is datum-contingent not structural). *Computes:* validates the phi=0 control against c54.186, fits three production seam phases on matched acoustic orders 4-7, asserts the intercept span and the stable spacing (5 checks) *Bound:* NOT-A-PAPER-CLAIM — a measurement; informs vein L-202, answers lead L-171; conversion to a PO-7 verdict is unseated *Run:* `python3 receipts/L147_two_arm/B7_the_seam_phase_m`

`K1_a_capability_assumed_from_one_failure` [OK]
sec:coherence (the whole acoustic disagreement is the driving: undriven the arms agree to 0.013 in phi/pi and the CR slope is exactly 1.0000 l_A, and both lines accepted a capability claim for eight revisions). *Computes:* fits all four production spectra, asserts the undriven agreement and the 5.72x driving ratio, and counts this lines own tarball absorptions (12 checks) *Bound:* NOT-A-PAPER-CLAIM — verifies c54.193-194 *Run:* `python3 receipts/L239_capability_assumed/K1_a_capability_as`

`B8_the_zero_velocity_band_is_a_third_of_the_gap` [OK]
sec:coherence (the seam datums band across the two ZERO-VELOCITY phases is 0.207 against a 0.615 disagreement — a third, not most — and over that pair the control is NOT inside). *Computes:* solves sin(phi)=0 on [0,2pi), reads both admissible phases off four production spectra from two nodes, and withdraws this lines own L-202 link (13 checks) *Bound:* NOT-A-PAPER-CLAIM — narrows c54.195s withdrawal *Run:* `python3 receipts/L147_two_arm/B8_the_zero_velocity_band_is_a_third_of`

P15R89 `P15_the_admissible_band_is_a_third_and_the_two_entries_differ_against_the_potential` [OK]
sec:coherence, sec:refit-bound (**ITEM 43 (r2509) ACCEPTED: OVER THE PHASES THE CORPUS ADMITS, THE ACOUSTIC PHASE MOVES 0.207 — A THIRD OF THE 0.615 GAP — AND THE CONTROL'S 0.263 IS OUTSIDE IT. THE DISAGREEMENT IS REAL AND BOUNDED.** Front #2, lead 'L-513'; VEIN 'L-202'. **PART 1** the pair is **forced**, not chosen: 'sec:what-crosses' says what crosses is **frozen**, a frozen mode has $\{}dot\{}delta_\{}gamma=0$, continuity gives $\{}theta_\{}gamma=\{}tfrac34Dkc_s\{}sin\{}phi$, so $\{}sin\{}phi=0$ — the paper's own transmission argument read at the seam, in print before the scan existed. **PART 2 AND THE REASON c54.199 GAVE 56 IS WRONG:** 'y0[:,6] = Ph0' is fixed at -1 independent of $\{}phi$ while 'dg0' carries $\{}cos\{}phi$, so the two entries are **not** a sign flip of the state — **what reverses is the relative sign of the density against the potential**, a compression against a rarefaction in the same well. **PART 3** 54's and cc54's production spectra agree to four decimals at both admissible phases. **PART 4** band 0.2069 vs gap 0.6152 — **2.97×**, control **outside** [0.6711, 0.8780]. **PART 5** $\{}chiˆ2/$dof **281 and 379** against 3.71 — 76× and 102× — so c54.195's PART 5 conclusion is stronger on the pair than on the span it was illustrated in. **PART 6** and P15 'sec:refit-bound' already carried "spans a third of it" and the 0.408, **two paragraphs above the paragraph that withdrew it**.). *Computes:* the four-step admissibility chain asserted in the instrument's AND the paper's source — **if 'sec:what-crosses' did not say modes freeze, the pair would be a choice and r2509 weaker than this file claims**; 'dg0' asserted to flip while 'Ph0' does not, which is what makes item 17's reason wrong; **54 and cc54 asserted to agree to four decimals — a band measured on one node's spectra is a band measured once**; the

ratio ~3 and, separately, the control asserted OUTSIDE the band, without which c54.195 stands as written; both admissible readings asserted above 50× the control, without which the withdrawal takes the conclusion with it; and the paper's own earlier 0.408 asserted to reproduce *Bound:* **!! SUPERSEDED BY P15_two_arm_control_and_guard (r4401).** *Headline claim withdrawn by a later revision of 'sec:refit-bound'; the only citation available would put back into the paper what the paper removed — attempted r4397, reverted r4399. **Kept, not deleted: the scans stand and this is the record of how the arc reached its present state.*** **scope: this corrects this line TWICE and in opposite directions — it makes the disagreement firmer than c54.195 left it, and it retracts the explanation c54.199 routed to 56. 'F5' unsoftened; 'PO-7' protected; the conversion runs by 'F5''s stated procedure. No new run: five banked production spectra, two nodes.** *Run:* `python3 receipts/P15_CR_cosmology/P15_the_admissible_band_is_a_third_and_the_two_entries_differ_against_the`

`B9_the_admissible_pair_is_forced_not_merely_distinguished` [OK]
sec:what-crosses (the admissible pair phi in {0,pi} is FORCED by P15s own transmission argument — every mode freezes before the crossing, and a frozen mode has zero velocity). *Computes:* quotes the freezing argument at source, solves sin(phi)=0, and asserts the control lies OUTSIDE the band with both nodes agreeing to four decimals (12 checks) *Bound:* NOT-A-PAPER-CLAIM — verifies c54.200 and upgrades r2509 *Run:* `python3 receipts/L147_two_arm/B9_the_admissible_pair_is_forced_not_me`

`B10_the_thermal_mechanism_needs_an_exponential_approach` [OK]
sec:transmission (L-519 answered from the MECHANISM side: thermality needs an exponential near-horizon approach, the degenerate members is a power law, and P15 already derived that split for its transmission dichotomy). *Computes:* integrates the tortoise coordinate for a simple and a double root, re-verifies the Nariai double root, and asserts P15s exponential/power-law split at source (11 checks) *Bound:* NOT-A-PAPER-CLAIM — a third footing for L-519; no temperature value claimed *Run:* `python3 receipts/L147_two_arm/B10_the_thermal_mechanism_needs_an_exponential_appr`

`PO-7` [OK]
sec:coherence (kill receipt for PO-7 under route (2): object named, four checks answered — and the CHAIN check does not clear, because the disagreement rests on four reproduced things and one ARGUED one). *Computes:* a kill receipt, not a script — the four checks written out with the inversion routes named *Bound:* NOT-A-PAPER-CLAIM — narrows PO-7; no authorisation requested *Run:* `python3 receipts/kills/PO-7.md`

`S1_every_mode_of_interest_freezes_and_the_inversion_is_closed` [OK]
sec:what-crosses (PO-7 chain-(4) link (d) reproduced on a second path: every mode of interest ell 28-2475 freezes before the crossing (r=c_s k/|aH| -¿ 0), so sin(phi)=0 forces phi in {0,pi}, the band stays 0.2069 with the control OUTSIDE, and the kill receipt's inversion (a mode crossing unfrozen) is closed by the divergence of |aH|). *Computes:* reproduces the progenitor interior independently (matching P16's freeze-out to the digit, x_freeze=0.002015 at ell=2475), computes the velocity ratio -¿ 0 at the crossing for every mode, and anchors sec:what-crosses + the kill receipt's chain check (10 checks) *Bound:* NOT-A-PAPER-CLAIM — reproduces PO-7's one non-reproduced link; informs L-171/L-202; F5 unsoftened, no conversion claimed *Run:* `python3 receipts/L805_freezing_reproduced/S1_every_mode_of_interest_freezes_and_the_inversion_is_closed.py`

`S1_a_massive_mode_freezes_too_and_the_mass_term_vanishes_at_the_branch_point` [OK]
sec:what-crosses (A2 (PO-seam / PO-7 inversion 3): a massive mode freezes too, for ANY mass — the branch point a-¿0 annihilates the mass term m^2 a^2 while |aH| diverges, so omega/|aH| -¿ c_s k x -¿ 0 independent of m; a massive trajectory carries no phase from non-freezing, closing PO-7 route 3 from the massive side). *Computes:* derives the mass term +m^2 a^2 from the covariant action (sympy), shows omega/|aH| at the crossing is m-independent to the digit up to m=1e5 across ell 28-2475, freeze-out epoch unmoved (5 checks) *Bound:* NOT-A-PAPER-CLAIM — A2; informs L-202/L-171; CRPHI stays assigned; F5 unsoftened *Run:* `python3 receipts/L806_massive_freezing/S1_a_massive_mode_freezes_too_and_the_mass_term_vanishes_at_the_bran`

`S1_the_peak_estimator_recovers_a_set_phase_independent_of_the_envelope` [OK]
sec:coherence (A10 (PO-7 inversion 2): the peak-4-8 estimator recovers a SET asymptotic phase to ¡0.005 in phi/pi and is envelope-independent (spread ¡0.006) across six damping/width/tilt variations spanning the CR-vs-control transfer differences — so the 0.408 is not an estimator artefact; inversion route 2 closes and the disagreement hardens). *Computes:* injects synthetic acoustic combs with known phi_in under six envelopes, runs the exact B7/B8 estimator, checks faithfulness and

envelope-invariance (4 checks) *Bound:* NOT-A-PAPER-CLAIM — A10; informs L-171; F5 unsoftened, no conversion claimed *Run:* `python3 receipts/L807_driven_estimator/S1_the_peak_estimator_recover`

`S1_the_seam_phase_is_derived_compression_correlated_on_the_observable_leg` [OK]
sec:what-crosses (PO-7/PO-seam: the seam phase CRPHI is DERIVED, not free = CRPHI=0 (a compression correlated with the well), on the observable leg — the pre-onset is pressureless (r2701) so no oscillation swings the inherited adiabatic overdensity's sign; bracket-checked against the LCDM control's own adiabatic IC; the {0,pi} band collapses to 0.878, disagreement pinned at 0.615, CRPHI=pi (0.408, a rarefaction) anti-adiabatic and inadmissible). *Computes:* reads the code's CRPHI convention (overdensity in a well = CRPHI=0), shows a pressureless mode's sign is fixed while a pressured one swings, confirms the adiabatic bracket, and anchors the pressureless-onset statement in CR_cosmology.tex (4 checks) *Bound:* NOT-A-PAPER-CLAIM — closes PO-7 route (3)'s residue; informs L-171/L-202; F5 unsoftened, one assumption (Phi-continuity) flagged *Run:* `python3 receipts/L815_seam_phase_derived/S1_the_seam_phase_is_derived_compression_correlated_on_the`

`S1_the_banked_spectra_are_nk600_not_nk260_and_pass_the_guard` [OK]
sec:where-the-likelihood-sits (corrects C52's sampling premise: the banked two-arm spectra the likelihood scores are NOT under-sampled — they are NK=600 (the README command), which PASSES the guard at 5.7 pts/Bessel-period. cc54 (15GB) reproduced c54.178_lcdm BIT-FOR-BIT (max |dDl|=8e-16). C52 read the .npz's 238-point shape as NK=260, but 238=len(arange(100,2000,8)) is set by LSTEP=8/LMAXL=2000, not NK; 56's 3.7GB container OOM'd at NK=600 so tested the guard-failing NK=260. The 7.14/280.09 stand; C51's dropped-bin point is separate and stands). *Computes:* confirms the 238-point shape is arange(100,2000,8) independent of NK, computes guard pts/period=2pi(3NK-1)/(LMAXL-12) giving 2.46@NK=260 (fails) and 5.69@NK=600 (passes), and asserts the banked npz is bit-identical to cc54's NK=600 reproduction (4 checks) *Bound:* NOT-A-PAPER-CLAIM — corrects C52's provenance premise; the guard itself is right (NK=260 does under-sample); does not touch C51's real dropped-bin blocker *Run:* `python3 receipts/L820_banked_spectra_sampling/S1_the_banked_spectra_are_nk600_not_nk260_and_pass_the_guard.`

`S2_the_lmax2512_extension_recovers_c51s_dropped_bins_and_CR_stays_disfavoured` [OK]
sec:where-the-likelihood-sits (discharges C51 (the damping-tail half of 56's resampling route): the LMAXL=2512 extension (302 multipoles to ell=2508) recovers the 30 dropped bins (ell 1759-2508), and including them does NOT rescue CR. Two effects isolated: the wider k-range lifts the control 7.14-¿3.81/dof on the SAME 185 bins (c54.186's truncation effect), added tail -¿3.68; the CR arm does not gain (280.1-¿281.1 overlap) and stays 260.1/dof. F3 widens 50497-¿51547 — the dropped region makes CR MORE disfavoured, not less). *Computes:* scores the LMAXL=2512 lcdm/cr extensions on the overlap (ell¡=1996) and full (201) bin sets vs the banked pair, isolating the k-range effect from the damping-tail addition, and computes F3 on both bin sets (4 checks) *Bound:* NOT-A-PAPER-CLAIM — the C51 half of L-820; CR verdict unchanged (both F3 ˜2400x threshold); control's 3.68/dof still large, truncation-vs-physics not further split *Run:* `python3 receipts/L820_banked_spectra_sampling/S2_the_lmax2512_extension_recovers_c51s_dropped_bins_and_CR_s`

`S1_the_cr_residual_is_acoustic_structure_not_truncation_and_that_is_why_it_is_unresponsive_to_lmax` [OK]
sec:where-the-likelihood-sits (PO-10 OWED #496 (the row's real remainder): DIAGNOSES the CR arm's 280/dof that r2781/C53 found "unresponsive to L_max and diagnosed by nothing". A per-bin chiˆ2 decomposition (full plik_lite covariance) localises the residuals: the control's is 75% in the high-ell tail (ell¿1200, the truncation), the CR arm's is 57% in the acoustic-peak bands (ell¡850) and 18% tail — so CR is acoustic-structure, not truncation, which is WHY it is unresponsive to L_max. CR comb compressed (172/404/636 vs sky 220/540/810, l1/lA 0.57 vs 0.73 = PO-7's deficit); rescaling doesn't collapse chiˆ2 (best ˜200) so position+heights). *Computes:* computes the per-bin chiˆ2 contribution r_i(Fr)_i with the full covariance and groups by ell-band for both arms, reads the CR peak positions, and scores under an ell-axis rescaling (4 checks) *Bound:* NOT-A-PAPER-CLAIM — OWED #496 CR half; F5 reserves the verdict (PO-7 protected); control third convergence point (L3200) measured separately *Run:* `python3 receipts/L822_cr_residual_diagnosed/S1_the_cr_residual_is_acoustic_structure_not_truncation_and_tha`

`S1_the_stored_cr_rs_is_the_from_onset_acoustic_horizon_and_matches_the_arms_own_integral` [OK]
sec:acoustic (PO-10 (the code read 56's r2790 routed): the stored CR r_s=135.46 is NOT a bookkeeping error. The line is R_S=rs_from(Z_START) with Z_START the FITTED onset; rs_from

uses the SAME sound speed/grid/onset the acoustic oscillation uses, so 135.46 IS the arm's acoustic horizon and the peaks asymptote to l_A=301.6. r2790's "peaks demand 158" is the low-ell transient (first-4-gap mean -¿ r_s=158, high-n gaps -¿ ~139 bracketing the stored); its "direction requires 245" is the from-a~0 horizon, NOT the acoustic one (pre-onset pressureless, L-815, no oscillations before onset). Smaller than LCDM because CR starts oscillating later — the framework's fitted-onset design). *Computes:* reproduces R_S=rs_from(Z_START) via the brentq fit, computes rs_from from a~0 vs the fitted onset for both arms, and reads the CR peak gaps by ell-range (first-4 vs high-n) (4 checks) *Bound:* NOT-A-PAPER-CLAIM — the r2790 code read; not a bug, the fitted-onset design's output; whether that design is forced is F5/PO-10's *Run:* `python3 receipts/L823_cr_rs_is_the_onset_horizon/S1_the_stored_cr_rs_is_the_from_onset_acoustic_horizon_and_`

`S1_the_third_point_shows_the_control_converges_by_L3000_and_the_unlensed_floor_is_the_lensing` [OK]
sec:acoustic (PO-10 (OWED #496, control half — the THIRD convergence point r2781 asked for): the control CONVERGES by L3000, it does NOT slide down an L^-3.4 law to "1.1 by L6000". On the same 185 bins the unlensed control goes 7.18→3.83→3.73→3.73 across LMAXL 2000/2512/3000/3200; the L^-3.4 law fit to the first two points predicts 2.23 at L3200, the measurement is 3.73 — the two-point rate was a one-time truncation recovery, not a convergence rate. The ~3.73 unlensed floor IS the lensing: c54.183's lensed/unlensed ratio takes the SAME converged spectrum 3.73→1.18, and the lensed control converges 5.38→1.33→1.19→1.18 to 1.18 by L3000 vs CAMB lensed's 1.014 (a ~0.16/dof instrument floor). Truncation (LMAXL) and lensing are ORTHOGONAL axes; F3 cancels the shared 1.18 floor). *Computes:* scores the four banked control spectra (c54.178 L2000, L820 L2512, c54.186 L3000, L824 L3200) on the fixed 185-bin set unlensed and under CAMB's lensed/unlensed ratio; checks the L^-3.4 extrapolation vs the measured third point, the L3000/L3200 convergence, and the top-bin truncation (4 checks) *Bound:* NOT-A-PAPER-CLAIM — control-arm convergence; does not overturn 56's convergence claim (the LENSED control does converge, to 1.18 by L3000); companion to L-822 (CR half); F5 untouched *Run:* `python3 receipts/L824_control_converges/S1_the_third_point_shows_the_control_converges_by_L30`

`S1_the_converged_controls_remainder_is_a_broadband_instrument_floor_not_a_localized_defect` [OK]
sec:acoustic (PO-10 (OWED #454, the remainder localized): after L-824's convergence the CONTROL arm's 1.18/dof vs CAMB lensed's 1.014 on the same 185 bins (the "~100" was pre-convergence, pre-lensing) is a BROADBAND instrument floor, not a localized defect. A per-bin r_i(Fr)_i decomposition shows every ell-band 100-2000 contributes a positive excess (+4.5/+6.0/+7.4/+1.6/+5.7/+4 total ~30 in chi^2), none dominating, slightly leading in the first two acoustic peaks (300-850 carries 13.4 of 30). So the ~1 target is instrument-accuracy-limited (a uniformly better transfer, not a patchable band), and F3=χ^2(CR)−χ^2(LCDM) cancels this shared floor). *Computes:* per-bin decomposition of the converged lensed control (L824 arm) and CAMB lensed LCDM through plik_lite TT's full covariance on the fixed 185 bins, by ell-band (3 checks) *Bound:* NOT-A-PAPER-CLAIM — control-arm diagnostic; #454's target instrument-limited, still open; F5 untouched; continues L-824 *Run:* `python3 receipts/L826_control_floor_broadband/S1_the_converged_controls_remainder_is_a_br`

`T1_the_transfer_is_half_built` [OK]
sec:envelope (PO-12 is HALF BUILT: the debt is two steps and step (1) — the specification of how fluctuations gravitate on the geometrically fixed background — is computed in sec:envelope, two sections before the debt is named). *Computes:* asserts the two-step sentence, the envelope-is-derived sentence, the structural-argument clause and the tilt-irreducible-residual clause verbatim (9 checks) *Bound:* NOT-A-PAPER-CLAIM — narrows a register row; step (2) is genuinely not run *Run:* `python3 receipts/L202_the_seam/T1_the_transfer_is_half_built.py`

P15R90 `C12_the_odd_even_half_has_its_parameter` [OK]
sec:envelope (PO-10s odd/even half already has its mechanism and parameter: C5b_baryon_term puts the asymmetry on the expansion leg at Rb=0.60, which is the rows own description of the item). *Computes:* asserts the rows wording, C5bs location and growth-factor and conclusion, and the papers own sentence (9 checks) *Bound:* NOT-A-PAPER-CLAIM — narrows a register row; the height pattern is not produced *Run:* `python3 receipts/P15_CR_cosmology/C12_the_odd_even_half_has_its_par`

P15R91 `C14_po12_gates_po10` [OK]
sec:envelope (PO-12 GATES both of PO-10s runs: the textbook odd/even ratios at R_b=0.60

are LCDM peak-height formulae that assume a transfer, and both of PO-10s halves are statements about C_l). *Computes:* asserts PO-10s remaining half and P15s genuine-build sentence verbatim, computes the textbook ratios, and confirms neither row records the dependency (7 checks) *Bound:* NOT-A-PAPER-CLAIM — records an ordering between two rows *Run:* `python3 receipts/P15_CR_cosmology/C14_po12_gates_po10.py`

P15R92 `C15_the_cancellation_does_not_reach_the_ratio` [OK]
sec:envelope-consequence (the corpuss cancellation does not reach the odd/even ratio: it holds between two RATES (same quantity, microphysics identical) while odd/even compares two MULTIPOLES on one rate, where the envelope leaves 13-36%). *Computes:* asserts the cancellation sentence and both rate-ratio results verbatim, and computes adjacent-peak envelope ratios on three envelopes (9 checks) *Bound:* NOT-A-PAPER-CLAIM — supplies the reason behind r2646s gate *Run:* `python3 receipts/P15_CR_cosmology/C15_the_cancellation_does_not_reach_the_ratio.py`

P15R93 `C16_the_transfer_is_six_eighths_built` [OK]
sec:envelope (PO-12s step 2 is six-eighths built: the driving verified in closed form, source removal exact, projection calibrated at l_*=302.2 vs 301, and a C_l RATIO with no free parameter already in the paper (0.823 recomputed vs 0.82)). *Computes:* verifies the driving satisfies its ODE, is even, and normalises; asserts the genuine-build, projection and no-free-parameter clauses verbatim; recomputes the high-ell ratio (8 checks) *Bound:* NOT-A-PAPER-CLAIM — narrows a debt to the absolute spectrum *Run:* `python3 receipts/P15_CR_cosmology/C16_the_transfer_is_six_eighths_built.py`

P15R94 `C17_the_instrument_already_carries_both` [OK]
sec:instrument (CORRECTS r2658: both pieces it marked NOT LOCATED are built and validated — the Peebles recombination history IS the visibility function and the line-of-sight source with its j_l kernel IS the projection). *Computes:* asserts sec:instruments description, its validation figures and its flat-projection wording verbatim, against the debt's geometric-background clause (9 checks) *Bound:* NOT-A-PAPER-CLAIM — corrects a prior lines audit; the debt is now what the instrument RUNS ON *Run:* `python3 receipts/P15_CR_cosmology/C17_the_instrument_already_carries_both`

P15R95 `C18_bespoke_means_two_legs` [OK]
sec:envelope (what BESPOKE means for PO-12: the transfer must carry TWO backgrounds joined at the branch point — radiation-dominated collapse leg, geometry-set expansion leg — and the paper forbids mixing the rates). *Computes:* computes the friction coefficient for both contents, asserts the collapse-leg scoping, the L1/L2 division and the forced consistency rule verbatim (7 checks) *Bound:* NOT-A-PAPER-CLAIM — sharpens a debt; the branch-point join is untouched *Run:* `python3 receipts/P15_CR_cosmology/C18_bespoke_means_two_legs.py`

P15R96 `C19_the_branch_point_join` [OK]
sec:transmission (THE BRANCH-POINT JOIN COMPUTED: transmission is conservation of R, so the join is a change of variable worth exactly 9/10 — applied ONCE where LCDM spreads it over equality, which is why CR has no early ISW). *Computes:* asserts the not-yet-in-hand and transmits clauses, the matter-dominated-to-nine-orders and four-per-cent clauses verbatim, and derives 9/10 from R/Phi=(5+3w)/(3+3w) (7 checks) *Bound:* NOT-A-PAPER-CLAIM — super-horizon join only; sub-horizon modes and the dynamical crossing stay open *Run:* `python3 receipts/P15_CR_cosmology/C19_the_branch_point_join.py`

P15R97 `C20_the_caveat_named_an_empty_set` [OK]
sec:what-crosses (r2661s super-horizon caveat named an EMPTY SET: at the branch point (rH)ˆ2 diverges, the comoving horizon goes to zero, and every mode is outside — so the 9/10 join is unrestricted). *Computes:* asserts the every-mode-outside and seam clauses verbatim, computes the divergence of (rH)ˆ2 and the vanishing comoving horizon, and confirms the radiation term dominates (7 checks) *Bound:* NOT-A-PAPER-CLAIM — removes a caveat from a prior receipt; the crossing dynamics stay deferred *Run:* `python3 receipts/P15_CR_cosmology/C20_the_caveat_named_an_empty_set.py`

P15R98 `C21_the_superhorizon_transfer_closes` [OK]
sec:envelope (THE SUPER-HORIZON TRANSFER CLOSES: Phi -¿ Phi_i exactly at the branch point for every k (departure O(kˆ2 etaˆ2)), so with r2661s join Phi_exp(k) = (9/10) Phi_i(k) scale-invariantly — the branch point does not filter). *Computes:* computes the branch-point limit and the series coefficients, re-derives the join, and asserts the transmits clause verbatim; flags the 1/10 near-miss as different-origin (7 checks) *Bound:* NOT-A-PAPER-CLAIM — scalar super-horizon only; the single end-to-end run stays unrun *Run:* `python3 receipts/P15_CR_cosmology/C21_the_superhorizon_t`

P15R99 `C22_the_end_to_end_number` [OK]
sec:earlyisw (THE END-TO-END NUMBER: 7.5% low-ell power deficit from the absent early ISW, 18% at l_D rising to 54% at 2 l_D from damping — and the acoustic peaks BETWEEN them are where the chain stops, correcting r2661s no-further-evolution). *Computes:* asserts the scope qualification, the super-horizon-equation clause, the order-two decay and the not-a-radiation-effect clause verbatim, and computes both ratios (8 checks) *Bound:* NOT-A-PAPER-CLAIM — corrects a prior receipts scope; not a prediction against data *Run:* `python3 receipts/P15_CR_cosmology/C22_the_end_to_e`

P15R100 `C59_the_control_reproduces_camb_and_the_height_defect_was_k_truncation` [OK]
sec:coherence (**PO-24 STEP ONE: THE CONTROL RUN, AND IT COMES OUT THE OTHER WAY. THE HEIGHT MACHINERY IS NOT BROKEN.** 'PO-24' records the bespoke transfer as getting the positions right and the HEIGHTS wrong by 22.7% and 97.5% on the arm whose answer is known, and the r3869 handoff named the live lead: two projection paths that are not the same physics, with **which one produced the 2.721 not established**. ** (1) IT WAS los_spectrum, AND THAT IS THE SMALLER HALF. ** '_project' also carries the polarisation source g Pi/4 + (3/4k^2) d^2[g Pi], so the comparison to CAMB was not like for like. ** (2) THE LARGER HALF NOBODY HAD LOOKED FOR: THE k-INTEGRAL IS TRUNCATED WHERE IT IS NOT CONVERGED. ** The instrument built its k-grid from LMAXL – the grid of multipoles to PRINT – so choosing what to report chose where to stop integrating C_l = INT P(k) Delta_l(k)^2 dk. Reported ell grid held FIXED and k_max alone moved: **2.721 -¿ 2.446 -¿ 2.399 -¿ 2.393**. ** (3) BOTH ARE NEEDED AND NEITHER ALONE SUFFICES. ** los_spectrum at converged k_max gives 2.393; _project at truncated k_max gives 2.516; both together give **2.197**. ** (4) THE RESULT: THE CONTROL REPRODUCES CAMB. ** Peaks **220 / 540 / 812** against the sky 220.6 / 538.1 / 809.8, **P1/P2 = 2.197 against CAMB 2.200 – 0.14%** and inside the sky's 1 sigma; P1/P3 = 2.192 against 2.277. Converged in k_max and stable to 2e-3 over a 1.5-fold change in mode count. ** (5) THE FORK IS SETTLED: REPAIR. ** The two-arm architecture carries the transfer; a fresh build would have discarded a working instrument on the strength of an artefact. ** (6) AND THE RECORDED LN SCAN IS INERT: ** LN=12 and LN=25 give identical ratios to 1e-3 with the state vector genuinely wider, against a recorded 4.496 -¿ 8.009.). *Computes:* the recorded 2.721/4.496 asserted REPRODUCED (so the row is not wrong about what it ran); k-truncation asserted to move both ratios on ONE path; the polarisation source asserted to move them again at converged k_max; NEITHER-ALONE asserted; the headline asserted within 1% of CAMB; every peak asserted within 9 of the sky's; convergence asserted to 2e-3 across NK 280 vs 420; Jac_of asserted == 1 to 1e-12 on the control so r3512's HIER composition defect cannot reach this result; LN inertness asserted with the state width checked. **CONTROL THAT FIRES: at the TRUNCATED k_max the same NK widening is EQUALLY STABLE and equally WRONG** – so stability in the knob you varied is not convergence, which is the defect this receipt removes *Bound:* ** CONTROL ARM ONLY. No CR number is produced or corrected. ** The CR arm is truncated by the same mechanism and is NOT re-measured; r3512's HIER composition defect is a no-op on the control (Jac == 1) and stays LIVE for CR, which the next step must settle first. NOT CLAIMED: that the bespoke transfer is finished, that PO-24 is closed, or anything about CR's peak heights. What is established is that its control works *Run:* `python3 receipts/P15_CR_cosmology/C59_the_control_reproduces_camb_and_the_height_defect_was_k_truncation.py`

P15R101 `C60_the_hier_composition_defect_names_two_flags_its_own_tree_never_had` [OK]
sec:coherence (**THE DEFECT FOUR DOCUMENTS DEFER TO IS NOT IN THE INSTRUMENT, AND WAS NOT IN THE ONE IT WAS WRITTEN AGAINST.** 'C59' closed PO-24's control step and deferred the CR arm to r3512's 'HIER' composition defect – "the first thing the next step must settle" – and THE_REGISTER, INDEX and both appendices carry that deferral. ** (1) THE REMEDY NAMES TWO FLAGS ITS OWN TREE NEVER HAD. ** r3512's fix is "give the hierarchy's gravitational source the stacking clock and its diffusion the leaf", i.e. teach 'HIER=1' about 'SRCSTACK' and 'DIFFLEAF'; both occur **zero** times in ACOUSTIC_two_arm.py at 95559d53, the commit r3512 IS, whose 42 os.environ flags are listed. They were real on **6beeca84** (SRCSTACK x13, DIFFLEAF x3), which is **not an ancestor** of 95559d53 – two nodes, two lines, one instrument. ** (2) THE ASYMMETRY IT COUNTED IS 'sound_phase'. ** "The main path references two" counts evolve's RHS plus 'sound_phase', which is CALLED ONCE in the file, from inside 'qscan()', the QSCAN=1 diagnostic that computes no spectrum. Like for like: each ODE right-hand side carries the clock **once**, and **neither projection carries it at all** – true at HEAD and at 95559d53 alike. ** (3) THE TWO

RIGHT-HAND SIDES ARE THE SAME BYTES. ** Lines 576 and 959 are character-identical, as are the rate selections at 536 and 916, and every clock-or-source operation in ‘evolve‘ is in ‘evolve_hier‘. ** (4) AND IT MOVES: ** on ARM=cr toggling LEAFPERT changes evolve_hier’s returned state by 2.0 relative, so the hierarchy is not ignoring the clock. **=¿ C59’s deferral is discharged; what gates the CR arm is convergence in k, not a composition fix.**). *Computes:* SRCSTACK and DIFFLEAF asserted absent at BOTH 95559d53 and HEAD, with the 42-flag inventory printed; 6beeca84 asserted to carry them and asserted NOT an ancestor of 95559d53; 95559d53 asserted an ancestor of HEAD; the Jac_of call sites located by enclosing function at both commits with the RHS count asserted 1 and 1 and the projections asserted 0 and 0; sound_phase’s single call site asserted inside qscan’s line span; lines 576/959 and 536/916 asserted character-identical; the operation set of evolve asserted a subset of evolve_hier’s; Jac_of asserted != 1 on ARM=cr and the LEAFPERT toggle asserted to move evolve_hier’s state. **CONTROL THAT FIRES: the receipt EXITS 1 rather than passing if 95559d53 is not in the clone** – a shallow checkout makes every PART 1 assertion vacuous, which is the hollow-assertion failure the fork names *Bound:* ** ESTABLISHES AN ABSENCE, NOT A CORRECTNESS. ** That the named defect is not there; NOT that the HIER path is right. No CR number, no peak position and no height ratio is produced. r3512’s gate order 1, 2 and 4 – validate Pi on the control, the PISRC subtraction, the CR run – are untouched and remain PO-13 Run 1’s business. NOT CLAIMED: that r3512 was careless; two lines of work on one file is a corpus-mechanics failure *Run:* `python3 receipts/P15_CR_cosmology/C60_the_hier_composition_defect_names_two_flags_its_own_tree_never_had.py`

P15R102 `C62_the_diffusion_signature_is_a_wash_and_the_isw_is_not_what_it_turned_on` [OK] *sec:coherence* (**PO-24: THE DIFFUSION-SCALE SIGNATURE IS RELOCATED INTO THE INFERRED TILT — NEITHER A TT-SHAPE TENSION NOR A WASH.** PO-24, narrowed at r4337, asks what the enlarged r_D does to the OBSERVED high-ell power, ”which turns on a parameter refit and on the early ISW term”. ** (1) THE JUDGEMENT: the early ISW is carryable, and the leaf assignment MULTIPLIES it rather than creating it. ** _rt, which sets the radiation fractions in the perturbation source, is the stack ”both arms” by the instrument’s own comment, so radiation is in the source under either assignment; measured, the post-recombination ISW is 0.348 of the SW amplitude on the leaf against 0.229 on the stacking rate. ** (2) BUT NOISW REACHED NO REPORTING PATH ** – read at one site in main()’s analytic block, zero references in los_spectrum, _project and hier_run – so the switch for the term this row turns on measured nothing. Repaired r4492; asserted at source here. ** (3) THE EARLY ISW IS NOT WHAT A HIGH-ELL QUESTION TURNS ON: ** 3.49 sigma/bin over l = 100-1296 and **0.77 sigma/bin over 700-1296**, propagated against plik_lite rather than quoted as a fraction. ** (4) THE SIGNATURE THROUGH A REFIT. ** Scaling r_D by the measured ratio multiplies the damping by a GAUSSIAN in ell; a tilt is a POWER LAW. Imposed on the measured sky and refitted on amplitude and tilt: **0.26 chiˆ2/bin over P15’s 185-bin ceiling, and MORE completely absorbed the higher one looks** (0.06/bin over 700-1760, 96% over 1000-2508) – because over a restricted range a Gaussian looks like a power law. ** (5) BUT THE ABSORPTION IS NOT FREE: dn_s = -0.0304 against sigma = 0.00323 derived from the SAME covariance that scores the fit – a 9.4 sigma cost. ** On the instrument’s own DSCAN pair the same fit gives 0.92/bin and 22.7 sigma. **The signature does not vanish under a refit; it MOVES, out of TT shape and into an inferred parameter.**). *Computes:* the r4492 repair asserted at source in both paths; r_D measured from the instrument at 7.1033 and 7.6398 Mpc, +7.55% raw, with DAMPX asserted to BE that ratio squared; the ISW’s imprint asserted larger on the leaf and asserted under 1 sigma/bin at high ell; the 185-bin ceiling asserted; the shape residual asserted under 0.6 sigma/bin on the data route and under 1.1 on both; the tilt cost asserted above 5 sigma on both routes. **CONTROL THAT FIRES: an injected tilt of +0.02 and +0.05 is recovered to within 5% with ¿99.9% absorbed** – a fitter that reports absorption is shown not to be manufacturing it *Bound:* ** THE MAGNITUDE IS NOT ROBUST TO A FACTOR OF THREE AND THE RECEIPT SAYS SO. ** The data-shape route multiplies the final spectrum by the Gaussian; the instrument applies the damping inside the source where it also enters the Doppler term through a derivative, on an unlensed ceiling-limited spectrum. The two differ 3.6x in residual and 2.8x in tilt; the larger is the more faithful route, so the wash is stated at the WEAKER bound and closing the factor of three is named as work not done here. NOT CLAIMED: that the CR arm as a whole is consistent (r4136 has its heights at -20.7% and -29.2%); that dn_s of this size IS a tension, which is a statement about a joint fit this receipt does not perform. **A FORTIORI, BOTH WAYS: on the SHAPE residual, freeing only the named degeneracy is the least absorption a real refit could achieve, so the wash is a bound; on the

TILT it is NOT a bound, since more parameters would SHARE the displacement** *Run:* `python3 receipts/P15_CR_cosmology/C62_the_diffusion_signature_is_a_wash_and_the_isw_is_not_what_it_turned_o`

P15R103 `C61_the_undriven_premise_is_false_on_the_rate_the_framework_assigns_the_perturbations` [OK]
sec:coherence (**PO-13's DIAGNOSIS RESTS ON A CROSSING CENSUS, AND THE CENSUS COMES OUT THE OTHER WAY ON THE RATE THE FRAMEWORK ASSIGNS THE PERTURBATIONS.** P07 sec:frontiers states "the standard shift that carries it is universal only where every mode crosses the horizon while there is a plasma to be driven, and **on this rate the acoustic modes re-enter above the onset, so none of them does**", and PO13_WORKING_STATE gives the same premise as the structural reason the arm cannot reach the sky. **r3409 made LEAFPERT the default: the perturbations run on the LEAF congruence, and Hleaf carries the radiation term where the CR stacking rate does not.** Horizon crossing for the driving is a perturbation-sector event, so the census that decides the diagnosis has to be run on the leaf rate. ** (1) THE LEAF BACKGROUND HAS AN EQUALITY AND THE ONSET PRECEDES IT: ** z_eq = Om/Or - 1 = **3936** (eta 236.4) against the onset at z = **6761** (eta 180.4). ** (2) THE FIRST PEAK IS SUPER-HORIZON WHEN THE PLASMA STARTS: ** on the leaf, k_1/aH(onset) = **0.858 ¡ 1** for l_1 = 204, and it enters at **z = 5590**, above equality – a radiation-dominated crossing, **while there is a plasma**. ** (3) THE BAND IS NOT A SINGLE MODE: ** every l ¡ 237.7 enters after the onset and **155.6 ¡ l ¡ 237.7** enters in radiation. ** (4) AND THE OTHER RATE GIVES THE OPPOSITE ANSWER: ** on the stacking rate k_1/aH(onset) = **1.415 ¿ 1** (already inside) and the background carries no radiation term at all, so it has no equality and the sentence is not merely true there but necessary. **=¿ The diagnosis was stated on the rate that carries the ruler and tested against a spectrum computed on the rate that carries the content.** And r3733's leaf reading for l=220 reproduces at 0.926 against its 0.92 – the premise's refutation was already in the record as a caveat.). *Computes:* both sentences asserted present verbatim in CR_framework.tex and PO13_WORKING_STATE.md, with the same P07 paragraph asserted to name the leaf congruence; LEAFPERT asserted on and RAD_IN_RATE asserted off; the leaf rate asserted to exceed the radiation-free rate at a=1e-4 (read, not assumed); the onset asserted to precede leaf equality; the after-onset and in-radiation bands computed from the instrument's own aH/c splines and the latter asserted to CONTAIN l=204; l_1 asserted super-horizon on the leaf and sub-horizon on the stack; the stacking rate asserted equal to Om/aˆ3+OL to 1e-12 at a=1e-6 where a radiation term would have been 254x the rest; r3733's 0.92 asserted reproduced. **CONTROL THAT FIRES: the same census on the STACKING rate returns the diagnosis's own answer** – so the census is not a construction that refutes everything put to it *Bound:* ** REFUTES A PREMISE, DOES NOT MEASURE A MECHANISM. ** No claim that the acoustic residual is explained, reduced or removed, and no measurement of how large the driving these modes receive is – NODRIVE=1 is what measures that and is not run here. The position deficit is untouched: the converged arm reports l_1/l_A = 0.6764 against the sky's 0.7312 whichever way the premise falls. NOT A VERDICT ON P07's SENTENCE: "this rate" is ambiguous in that paragraph between the stacking rate the section is about and the leaf rate the same paragraph names, and the sentence is TRUE on the first; what is established is that the reading supporting the diagnosis is the one the rate rule does not select. NOT CLAIMED: anything about z_onset as a fitted parameter, the alternation, or the Hubble-tension join P07 makes next *Run:* `python3 receipts/P15_CR_cosmology/C61_the_undriven_premise_is_false_on_the_rate_the_framework_assigns_the_p`

P15R104 `C63_no_single_source_term_carries_the_undriven_split_and_the_first_probe_read_an_unwired_knob` [PASS]
sec:coherence (**NO SINGLE LINE-OF-SIGHT SOURCE TERM CARRIES PO-13's 23% UNDRIVEN SPLIT.** Undriven, the CR arm's first peak sits at 1.1273 of its own angular acoustic scale and the control's at 0.9158 – a 23% split with Q=1 on both arms, so the oscillator is excluded and the split is in the projection. The DIFFUSION DAMPING is excluded too: DAMPX=0 removes it entirely and the split WIDENS to 26.0%. Removing the monopole, the Doppler dipole and the integrated term ONE AT A TIME leaves the split at 23.1%, 23.8% and 29.4% – it never collapses, and removing the integrated term WIDENS it. So the answer to "Psi, integrated, or Doppler" is NONE OF THE THREE. ALSO PINS THE ROW'S PREMISE: "the same acoustic scale on both arms" is TRUE of the ANGULAR scale l_A (301.6 vs 301.4, 1 part in 1507) and FALSE of the PHYSICAL sound horizon r_s (135.46 vs 144.53 Mpc, 6.3% apart). The l_A match is a conspiracy – D_M differs by 6.2% too, within 0.07% of r_s's own difference – not

a shared scale.). *Computes:* eight runs of ACOUSTIC_two_arm.py under NODRIVE=1, both arms x (baseline, NOISW=1, DPSRC=0, SWSRC=0), at LMAXL=520 where all eight first peaks reproduce the LMAXL=1300 values exactly; each switch is CALIBRATED before any null is read off it *Bound:* A NEGATIVE result: it says where the split is NOT and is not a mechanism. Only SINGLE removals were run, so a cancellation between two terms is not excluded. The damping half of the projection kernel is now excluded and the VISIBILITY half is not: the arms last-scatter at eta = 449.6 and 280.8, a 60% difference in epoch against 7% in width, and that is the named unrun candidate. ZSTART is NOT a free knob – r_s integrates from the start, so moving it moves the acoustic scale itself (a trial took l_A from 301.6 to 172.8). Does not touch the driving (DRC/DRE are identically zero under NODRIVE=1). The KCONT=1 sampling control leaves all four CR peaks unchanged, which bounds the sampling shift below one LSTEP=8 grid step (2.65%) against a 23% effect – a bound, not an identity. *Run:* `python3 receipts/P15_CR_cosmology/C63_no_single_source_term_carries_the_undriven_split_and_the_first_probe_`

P15R105 `C23_the_gap_estimated` [OK]
sec:earlyisw (ESTIMATE for the peak-region gap: the decay rate k^2/(3H) is built from the thing that differs, so CRs potential decays ~15% faster and the peak power ratio is ~0.813 — BROAD deviation, not tail-confined). *Computes:* asserts the rate, the 13% and the factor-of-two clauses verbatim, computes the compounding, and flags the 0.813/0.823 near-coincidence as different-origin (7 checks) *Bound:* NOT-A-PAPER-CLAIM — an ESTIMATE with its model stated, labelled as one; a hierarchy run would replace it *Run:* `python3 receipts/P15_CR_cosmology/C23_the_gap_estimated.py`

P15R106 `C24_the_substitution_itemised` [OK]
sec:instrument (PO-12s substitution ITEMISED: conformal time, r_s, the comoving horizon and the diffusion integral carry H while the Thomson rate and x_e do not — and the ratio does NOT cancel because r_D carries a square root that r_s does not). *Computes:* asserts the 13% clause and reconstructs it from rho_r/rho_m=0.3, asserts the microphysics-outside and theta_*-pinned clauses, and computes both scaling exponents (8 checks) *Bound:* NOT-A-PAPER-CLAIM — sets the bar for the two-leg run; P15s 9.4% is not re-derived *Run:* `python3 receipts/P15_CR_cosmology/C24_the_substitutio`

P15R107 `C25_the_gap_closed_by_integration` [OK]
sec:diffusion-scale (the 2.6-point gap closed by INTEGRATION: theta_D/theta_* runs +7.1% at z=1200 to +14.4% at z=10000, with P15s +9.4% at z~2500 — and the dependence is MONOTONIC, which is the papers own two-constraint argument). *Computes:* asserts the branch-point lower-limit clause and the single-datum clause verbatim, integrates the rate difference over five onset redshifts, and checks monotonicity (6 checks) *Bound:* NOT-A-PAPER-CLAIM — reproduces the papers shape on a simplified rho_r/rho_m model; the onset is the remaining unknown *Run:* `python3 receipts/P15_CR_cosmology/C25_the_gap_closed_by_integration.py`

P15R108 `C26_the_onset_is_not_free` [OK]
sec:tensions (PO-12s last free parameter is NOT free: the onset is fitted to the acoustic angle at z~6797 and meets the scale at every H_0 — and the residual +13.1% vs +9.4% is the WEIGHT g(R)/x_e, not the onset). *Computes:* asserts the onset value, the fitted-to-the-acoustic-angle clause and the not-a-knob clause verbatim, checks the model at the onset, and integrates under four weightings (7 checks) *Bound:* NOT-A-PAPER-CLAIM — power-law weights are stand-ins for g(R)/x_e, shown for direction and size *Run:* `python3 receipts/P15_CR_cosmology/C26_the_onset_is_not_free.p`

P15R109 `C27_the_number_bracketed` [OK]
sec:envelope-consequence (P15s +9.4% BRACKETED from outside its own machinery: Saha +7.0% ¡ Peebles ¡ unweighted +13.1%, with the ordering FORCED by which history recombines faster — and cancel identically covers the CONSTANTS, not the weight). *Computes:* asserts the cancel-identically, constants-outside and Peebles-history clauses verbatim, shows the weight does not drop out, runs g(R) with a Saha x_e, and checks 9.4 lies strictly inside (8 checks) *Bound:* NOT-A-PAPER-CLAIM — brackets rather than reproduces; the Peebles direction is argued, not computed *Run:* `python3 receipts/P15_CR_cosmology/C27_the_number_bracketed.py`

P15R110 `C28_length_against_angle` [OK]
sec:envelope-consequence (THERE WAS NEVER A DISCREPANCY: 9.4% is an ANGLE ratio (C10s r=1.0926, already netting the 0.7% sound-horizon shift) and 10.8% a LENGTH ratio (C8) — r2686-r2689 compared one to the other). *Computes:* asserts both statements and the 0.7% clause verbatim, reads C10s own r, and shows the two do not compose as this line assumed (7

checks) *Bound:* NOT-A-PAPER-CLAIM — corrects four of this lines revisions; C8 and C10 are run, not re-derived *Run:* `python3 receipts/P15_CR_cosmology/C28_length_against_angle.py`

P15R111 `C29_nothing_to_calculate_across_the_join` [OK]
sec:what-crosses (PO-12s remaining half has NO CONTENT: the pre-onset stretch is pressureless and at w=0 the potential equation loses k entirely, so there is no scale-dependent evolution for a single calculation across the join to compute). *Computes:* asserts the no-k, pressureless, boundary-mode and residue clauses verbatim, and verifies symbolically that k is present in the general equation and absent at w=0 (7 checks) *Bound:* NOT-A-PAPER-CLAIM — F5 reserves the strike; the residue routes to PO-7 *Run:* `python3 receipts/P15_CR_cosmology/C29_nothing_to_calculate_across_the_joi`

P12R15 `A7_the_frontier_has_two_kinds` [OK]
sec:envelope-consequence (THE FRONTIER SORTS INTO TWO KINDS on P15s own H(a) rule: FIVE rows ask whether the theory is DEFINED (PO-2/4/5/6/11) and TWO ask what it PREDICTS (PO-7/10) — and they fail differently, so size does not order them). *Computes:* asserts the H(a) clause, checks the classification covers exactly the open rows, and pins each rows object against its kind (7 checks) *Bound:* NOT-A-PAPER-CLAIM — the classification is derived here; no paper states it *Run:* `python3 receipts/P12_algebroid/A7_the_frontier_has_two_kinds.py`

P15R114 `C32_half_one_is_model_selection` [OK]
sec:frontiers (PO-10s half (1) IS an information-criterion comparison: the corpus names "the likelihood-level model selection" while AIC/BIC/Akaike/Occam/Bayes-factor appear ZERO times — and the penalty is computable now, dAIC=10.0 and dBIC=26.9 in CRs favour). *Computes:* asserts the model-selection phrase and the 215-bin count verbatim, word-boundary-checks five model-selection terms at zero across papers and receipts (excluding itself), and computes both penalties (9 checks) *Bound:* NOT-A-PAPER-CLAIM — k=6 is the standard flat-LCDM count and must be stated with any result; the chi^2 is unrun *Run:* `python3 receipts/P15_CR_cosmology/C32_half_one_is_model_se`

P15R115 `C33_the_threshold_corrected` [OK]
sec:tensions (THE THRESHOLD CORRECTED: r2709s k=1 was wrong — P15 anchors A_s at the first peak, so CR is k=2 — and against Liddle/Jeffreys (dBIC 2 positive, 6 strong) the threshold is dBIC = 21.5, still 3.5x the strong line). *Computes:* asserts the anchored-amplitude and one-parameter-accommodation clauses verbatim, tables all four parameter-count pairs against the Jeffreys scale, and computes the AICc correction (7 checks) *Bound:* NOT-A-PAPER-CLAIM — no chi^2 is scored; the count must be restated with any result *Run:* `python3 receipts/P15_CR_cosmology/C33_the_threshold_corrected.py`

P15R116 `C34_the_deliverable_is_a_pair` [OK]
sec:tensions (PO-10s DELIVERABLE IS A PAIR: the acoustic sector is open as PO-7, its phase freedom moves the gap 0.615 -¿ 0.408 and cannot close it — but the freedom is DISCRETE, so k is unchanged and both branches are reported at the same threshold). *Computes:* asserts PO-7s object, the phase-lever and cannot-close clauses verbatim with both values, and shows the discrete choice leaves dBIC at 21.5 rather than 16.1 (5 checks) *Bound:* NOT-A-PAPER-CLAIM — neither branch is scored; that is the whole of what remains *Run:* `python3 receipts/P15_CR_cosmology/C34_the_deliverable_is_a_pair.py`

P15R117 `C35_the_reference_is_F3` [OK]
sec:tensions (THE REFERENCE FORK SETTLES ITSELF AND AGAINST THIS LINES FRAMING: BIC uses only DIFFERENCES, so F3 (same-instrument) is the score and the CAMB-206.4 comparison charges CR an instrument floor CAMB never pays). *Computes:* asserts L-147s floor definition and pipeline-wiring clauses verbatim, shows dBIC contains only a chi^2 difference, and confirms the threshold is invariant under the pair choice (7 checks) *Bound:* NOT-A-PAPER-CLAIM — corrects r2709-r2711s statement of what the threshold scores against; the threshold itself is unchanged *Run:* `python3 receipts/P15_CR_cosmology/C35_the_reference_is_F3.py`

P15R118 `C36_the_negative_is_the_envelope` [OK]
sec:envelope-consequence (SUPERSEDED r2725 (the check shared the runs own n_s-held assumption, so agreeing to the same order confirmed only that both held it fixed) — L-814s NEGATIVE IS NOT AN ARTEFACT: P15s own published envelope, scored against cosmic variance on 215 bins with no pipeline or fit, gives chi^2 ~ 1.6e5 against cc54s measured 5.05e4 — the same order). *Computes:* evaluates the papers own exp[-(l/l_D)^2(r^2-1)] across the band, scores it against cosmic-variance errors, reads cc54s floor finding from their receipt, and pins L-147s scope clause (6

checks) *Bound:* NOT-A-PAPER-CLAIM — no framework verdict; PO-7 protected and F5 reserves it *Run:* `python3 receipts/P15_CR_cosmology/C36_the_negative_is_the_envelope.py`

P15R119 `C37_the_comparison_is_not_matched` [OK]
sec:envelope-consequence (L-814s COMPARISON IS NOT MATCHED and its number is WITHDRAWN as a result: the CR arm was held at k=2 with n_s fixed at LCDMs fitted value, and freeing the tilt alone removes 15.6x). *Computes:* computes the envelope chi^2 with the tilt held and free, shows the threshold barely moves for the extra parameter, and reads cc54s own relative statement from their receipt (5 checks) *Bound:* NOT-A-PAPER-CLAIM — the k=2 spec was this lines at r2710; a matched comparison is not claimed to pass *Run:* `python3 receipts/P15_CR_cosmology/C37_the_comparison_is_not_matched.py`

P15R120 `C38_the_comparison_scores_derivations` [OK]
sec:tensions (PO-10s NON-FOREIGN COMPARISON IS A SCORE ON DERIVATIONS: a derivation has no k, so scoring theta_*, r, z_eq and the 9/10 transfer against measurement imports no parameter vector — and this receipt reports NO score, because the draft that did invented every sigma). *Computes:* pins P15s derived-vs-measured pairs and its own naming of Omega_m and A_s as fitted, and asserts its own refusal to score (6 checks) *Bound:* NOT-A-PAPER-CLAIM — no verdict on CR; the row owes published uncertainties and a derived-quantity list *Run:* `python3 receipts/P15_CR_cosmology/C38_the_comparison_scores_derivations.py`

P15R121 `C39_the_derived_list_read` [OK]
sec:tensions (PO-10s DERIVED-QUANTITY LIST READ from P15s own marker language: four pairs each with the papers own accuracy clause (theta_* 302.2/301, r_s 146.4/145.4, 1+z_eq 3399, eta 1.99 to one per cent) and three exclusions in the papers own words). *Computes:* pins all four derived pairs and all three fitted-exclusions verbatim, and the high-l ratios no-free-parameter clause (7 checks) *Bound:* NOT-A-PAPER-CLAIM — nothing is scored; the published uncertainties remain owed and are not this lines to invent *Run:* `python3 receipts/P15_CR_cosmology/C39_the_derived_list_read.py`

P15R122 `C40_the_pair_was_quoted_against_a_rounding` [OK]
sec:tensions (PO-10s FIRST PAIR MUST TAKE THE RECEIPTS VALUE, NOT THE PROSE: P15 writes "the measured ~301" (tilde present, honestly approximate) while P15_zonset_determinations carries and asserts l_A = 301.76 — and the gap is 0.44, not 1.20). *Computes:* quotes both the prose and the receipts assertion, computes both gaps, and carries its own first drafts correction (6 checks) *Bound:* NOT-A-PAPER-CLAIM — no paper edit owed, the tilde is there; nothing is scored and the uncertainty is still not this lines *Run:* `python3 receipts/P15_CR_cosmology/C40_the_pair_was_quoted_against_`

P15R123 `C41b_a_tilde_on_a_settled_value_is_a_stale_hedge` [OK]
sec:tensions, sec:coherence (A TILDE ON A SETTLED VALUE IS A STALE HEDGE: ~301 became 301.76 (asserted by its receipt) and ~8% became 8.2% in NINE places (computed on CAMBs exact ionization history), three of them while calling it "a real, computed effect"). *Computes:* confirms both figures are asserted by receipts, that no tilde survives on either, and that legitimately approximate tildes are untouched (7 checks) *Bound:* NOT-A-PAPER-CLAIM — nothing scored; not every tilde is stale, only those on figures a receipt asserts *Run:* `python3 receipts/P15_CR_cosmology/C41b_a_tilde_on_a_settled_value_is_a_stale_hedge.py`

P15R124 `C41_a_tilde_is_stale_when_nothing_competes` [OK]
sec:tensions (A TILDE IS STALE WHEN ONE RECEIPT ASSERTS AND NONE COMPETES: ~301 failed that test and P15 now reads 301.76; ~8% passed it — C8 derives +10.83% analytically and NAMES the disagreement with damping_ratio_cleans +8.2% — so nine edits were reverted). *Computes:* confirms the 301.76 edit landed and the nine tildes remain, pins C8s computed +10.83% and its own naming of the conflict (6 checks) *Bound:* PAPER-CLAIM (301.76 only) — the 8% figure is left tilde-marked and its discrepancy is filed as owed *Run:* `python3 receipts/P15_CR_cosmology/C41_a_tilde_is_stale_when_nothing_competes.py`

P15R125 `C42_the_cancellation_needs_xe_identical` [OK]
sec:coherence (THE DAMPING DISCREPANCY DIAGNOSED: C8s cancellation needs x_e identical in both cosmologies, and a different H(a) changes the recombination HISTORY not merely its epoch — Lambda, the upper limit, the radiation density and arithmetic all eliminated). *Computes:* reproduces C8 to six figures, varies Lambda / z_rec / rho_r and shows none accounts for the gap, and pins C8s own PROVIDED clause (7 checks) *Bound:* NOT-A-PAPER-CLAIM — neither

number is adjudicated; the x_e response is a calculation neither receipt has done *Run:* `python3 receipts/P15_CR_cosmology/C42_the_cancellation_needs_xe_identical.py`

P15R126 `C43_the_gap_is_numerical_not_xe` [OK]
sec:coherence (r2750 WITHDRAWN — THE DAMPING GAP IS NUMERICAL, NOT x_e: a pure H probe moves z_* by only 0.195% (~0.05pp on the ratio) against a 1.86pp gap, while the CAMB receipt prints a 7.1% miss against CAMBs own thetad on its OWN LCDM arm). *Computes:* runs CAMB at five N_eff values as an H-only probe, scales the response by r2750s own measured sensitivity, and pins the receipts self-reported GATE miss (6 checks) *Bound:* NOT-A-PAPER-CLAIM — C8 is not confirmed, and the tilde stays: two receipts still disagree, one now with a KNOWN defect *Run:* `python3 receipts/P15_CR_cosmology/C43_the_gap_is_numerical_not_xe.py`

P15R127 `C44_the_gap_is_truncation` [OK]
sec:coherence (THE DAMPING GAP IS TRUNCATION: the r_D ratio climbs 8.33% -¿ 9.94% with the upper limit and converges only by z~5e4, while the CAMB receipts grid stops at z=12000 — and a normalisation factor CANCELS in a ratio, which withdraws r2751). *Computes:* computes the ratio at six upper limits, shows convergence, and demonstrates that a shared constant divides out (6 checks) *Bound:* NOT-A-PAPER-CLAIM — the receipts grid is reasonable for its own purpose; what is claimed is that its RATIO inherits a truncation bias *Run:* `python3 receipts/P15_CR_cosmology/C44_the_gap_is_truncation.py`

P15R128 `C45_xe_does_not_cancel_from_a_ratio_of_integrals` [OK]
sec:coherence (THE DAMPING DISCREPANCY RESOLVED: x_e does NOT cancel from a ratio of INTEGRALS even when identical — toggling it on the same range moves the ratio +9.94% to +8.37%, the whole gap — so C8s cancellation step is a real error). *Computes:* toggles x_e on a fixed range and measure with CAMBs own history, shows a shared CONSTANT does cancel exactly while x_e does not, and pins C8s every-constant-outside claim (6 checks) *Bound:* NOT-A-PAPER-CLAIM — which figure is P15s signature is not settled; C8s reduction and baryon correction stand *Run:* `python3 receipts/P15_CR_cosmology/C45_xe_does_not_cancel_from_a_ratio_of_integrals.py`

P15R129 `C46_the_nine_are_right_and_the_one_is_wrong` [OK]
sec:tensions (THE 9.4% TRACED: P15 -¿ C10 (+9.26%) -¿ C9, which divides r_D 1.1015 by r_s 1.0067 — the ANGLE ratio, correctly, but from an r_D that omits the x_e weighting. Corrected it lands at +7.6% to +8.2%, so the nine ~8% were RIGHT and the one 9.4% was the error). *Computes:* pins the citation chain P15-¿C10-¿C9 and reruns C9s own division on three r_D ratios (6 checks) *Bound:* PAPER-CLAIM — ten instances set to 8.2%, and the tilde removed per r2749s test now that nothing competes *Run:* `python3 receipts/P15_CR_cosmology/C46_the_nine_are_right_and_the_one_i`

P15R130 `C47_the_neutrinos_were_missing` [OK]
sec:coherence (THE +5.66% RECONCILED AND IT WAS THIS LINES ERROR: r2752 used photons alone where the receipt uses Ogamma + Onu (a 69% underestimate of what sources H) — and the CR arm has no radiation at all, so the omission hit ONE ARM ONLY. With neutrinos in, the ratio is 1.0896 against the receipts 1.0897). *Computes:* runs the full Hu-Sugiyama for both rates under two radiation densities with CAMBs own x_e, and confirms the absolute r_D difference cancels from the ratio (6 checks) *Bound:* NOT-A-PAPER-CLAIM — only the RATIO is claimed to four figures; the absolute r_D still differ by ~3% from grid and quadrature *Run:* `python3 receipts/P15_CR_cosmology/C47_the_neutrinos_were_missing.py`

P15R131 `C48_the_pairs_are_three` [OK]
sec:tensions (PO-10s PAIRS ARE THREE, NOT FOUR: r_s and 1+z_eq hold against asserting receipts (C9 145.38, DESI 3402), but the onset ratio is an IDENTITY ON INHERITED INPUTS — "the quoted value to one per cent, from standard thermodynamics" — same class as N_eff and A_s). *Computes:* finds the asserting receipt for each measured value, pins the thermodynamics clause, and records the 1.9968 near-miss where another receipt asserts a different quantity with the same digits (6 checks) *Bound:* NOT-A-PAPER-CLAIM — the onset ratio is not wrong, only not a TEST; nothing is scored *Run:* `python3 receipts/P15_CR_cosmology/C48_the_pairs_are_three.py`

P15R132 `C49_the_row_has_a_likelihood_not_a_lookup` [OK]
sec:tensions (PO-10 DOES NOT NEED ERROR BARS — IT HAS A LIKELIHOOD: plik_lite over 215 TT bins with a covariance and a banked LCDM fit the pipeline calls wired. What blocks it is recorded in the same file — the CONTROL arm lands at chi^2/dof ~ 100). *Computes:* pins the instrument, its calibration standard, its self-recorded F4 defect, and F5s protection of the verdict (6

checks) *Bound:* NOT-A-PAPER-CLAIM — the control defect is not diagnosed here, and no verdict on CR is drawn *Run:* `python3 receipts/P15_CR_cosmology/C49_the_row_has_a_likelihood_not_a_lookup.py`

P15R133 `C50_the_control_is_at_seven_not_a_hundred` [OK]
sec:tensions (THE CONTROL ARM IS AT 7.14, NOT ~100: the receipts F4 prose carried the c54.172 floor while its F6 PRINT reports 1320.5/185 = 7.14, and F6 says the floor fell 103 -¿ 22.5 -¿ 28.6 -¿ 7.1, a factor of 14). *Computes:* pins the corrected prose, the f-string print fields, the fall history, the 185-vs-215 bin difference and F6s unchanged verdict (6 checks) *Bound:* NOT-A-PAPER-CLAIM — 7.14 is not acceptable either; both arms remain outside the discriminating regime *Run:* `python3 receipts/P15_CR_cosmology/C50_the_control_is_at_seven_not_a_hundred.py`

P15R134 `C51_the_dropped_bins_are_the_damping_tail` [OK]
sec:tensions (THE THIRTY DROPPED BINS ARE ell 1759-2508 — THE DAMPING TAIL: the likelihood arms model ends near ell 1760 and nan-drops the rest, discarding exactly the region P15 names as its exposed edge, where the suppression runs 24% to 42%). *Computes:* reads the bin edges from the likelihoods own arrays, locates the cut at which 185 survive, and profiles the damping suppression across the dropped range (6 checks) *Bound:* NOT-A-PAPER-CLAIM — the ell limit is a cost not a mistake, and which way the omitted bins would land is the point of running them *Run:* `python3 receipts/P15_CR_cosmology/C51_the_dropped_bins_are_the_damping_tail.py`

P15R135 `C52_the_banked_spectra_fail_the_sampling_guard` [OK]
sec:tensions (THE BANKED SPECTRA FAIL THE INSTRUMENTS OWN SAMPLING GUARD: LMAXL=2000 NK=260 gives 2.5 points per Bessel period and prints UNDER-SAMPLED — and the guard says the source comb stays correct while the projection aliases, so no comb-level check could catch it). *Computes:* fixes the banked configuration from the npz shape, computes the sampling ratio and projection memory across four NK values, and pins the guards own wording (6 checks) *Bound:* NOT-A-PAPER-CLAIM — whether aliasing moves the chi^2 enough to matter is UNMEASURED, and measuring it needs a run that will not fit in 3.7 GB *Run:* `python3 receipts/P15_CR_cosmology/C52_the_banked_spectra_fail_the_sampling_guard.py`

P15R136 `C53_the_k_range_fixes_one_arm_only` [OK]
sec:tensions (THE k-RANGE FIXES ONE ARM ONLY: raising L_max 26% drops the control 7.14 -¿ 3.81 on the SAME 185 bins while CR moves 0.4% — a response ratio over twenty to one, so r2760s undiagnosed factor of seven is a k-truncation and CRs 281 is not). *Computes:* computes both arms responses and their ratio, checks F_3 widens in the direction one-arm improvement predicts, and labels the two-point trend as an extrapolation (6 checks) *Bound:* NOT-A-PAPER-CLAIM — radiation is the first candidate not a demonstrated mechanism; the convergence trend rests on TWO points *Run:* `python3 receipts/P15_CR_cosmology/C53_the_k_range_fixes_one_arm_only.py`

P15R137 `C54_the_281_is_the_prediction_being_measured` [OK]
sec:tensions (CRs 281 IS THE ORDER P15s OWN PREDICTION PRODUCES: scoring the damping residual over 185 bins gives chi^2/dof from 204 (sigma=1%) to 5099 (sigma=0.2%), so 281 sits INSIDE that range and BELOW the value at Plancks quoted errors — the arm is scoring the effect P15 predicts). *Computes:* pins P15s no-free-parameter high-ell formula, scores its residual at three error scales, pins F5, and names the SHAPE test that would settle it (5 checks) *Bound:* NOT-A-PAPER-CLAIM — an ORDER comparison against a flat sigma, not a derivation against the plik covariance; supplies a candidate, does not close the row *Run:* `python3 receipts/P15_CR_cosmology/C54_the_281_is_the_prediction_being_measured.py`

P15R138 `C55_the_shape_test_says_peak_misalignment` [OK]
sec:tensions (THE SHAPE TEST RUN: the CR arms residual is neither a damping-profile match nor flat — it OSCILLATES, 0.237 to 2.375, correlation -0.296, dominant period 317 against l_A = 301. The 281 is PEAK MISALIGNMENT, and r2786 is withdrawn by its own named test). *Computes:* computes the banked arms ratio, its correlation with P15s profile, its dominant Fourier period against l_A, and the l_A-agrees / r_s-differs contrast (5 checks) *Bound:* NOT-A-PAPER-CLAIM — the damping signature is not shown absent, only non-dominant; physical vs numerical phase slip is the open question *Run:* `python3 receipts/P15_CR_cosmology/C55_the_shape_test_says_peak_misa`

P15R139 `C56_la_is_computed_and_its_residual_is_too_small` [OK]
sec:tensions (l_A IS COMPUTED NOT CALIBRATED (pi D_M/r_s reproduces the stored value in both arms) and its survival is a real cancellation P15 claims in advance — but the +0.075% residual explains under 1% of r2787s measured swing, two orders too small). *Computes:* checks pi

D_M/r_s against the stored l_A in both arms, sizes the D_M and r_s moves, pins P15s met-from-the-other-end clause, and propagates the residual against the measured swing (5 checks) *Bound:* NOT-A-PAPER-CLAIM — the cancellation is observed not re-derived; amplitude is what remains after two eliminations, a candidate not a finding *Run:* `python3 receipts/P15_CR_cosmology/C56_la_is_computed_and`

P15R140 `C57_the_cr_peaks_are_not_at_its_own_la` [OK]
sec:tensions (THE CR ARMS PEAKS ARE NOT WHERE ITS OWN l_A SAYS: mean spacing 258 against a stored l_A of 301.6 (ratio 0.855) while LCDM sits at 0.995 — so the stored quantities are consistent with each other and NOT with the computed C_ell). *Computes:* finds peaks in both banked arms, compares mean spacing against each arms stored l_A, and sizes the mismatch against r2788s residual (5 checks) *Bound:* NOT-A-PAPER-CLAIM — which of D_M, r_s or the projection is wrong is not established; the CR spacing could be a real feature of a transfer on the geometric rate *Run:* `python3 receipts/P15_CR_cosmology/C57_the_cr_peaks_are_not_at_its_own_la.py`

P15R141 `C58_the_stored_rs_moves_the_wrong_way` [OK]
sec:tensions (THE STORED CR r_s MOVES THE WRONG WAY: removing radiation must RAISE the sound horizon (146.5 -¿ 245.2 Mpc integrated), the peak spacing independently demands 158.35, and the stored value is 135.46 — BELOW LCDMs 144.53). *Computes:* solves the spacing for each candidate, integrates r_s with and without radiation, and shows pi D_M/r_s on both stored values reproduces the stored l_A exactly (5 checks) *Bound:* NOT-A-PAPER-CLAIM — 158.35 and 245.16 are not proposed as the right value; what is established is the DIRECTION and that the stored value has the wrong sign of deviation *Run:* `python3 receipts/P15_CR_cosmology/C58_the_stored`

`R1_the_correction_stopped_at_the_sentence_and_the_number_it_defines_was_left_behind` [OK]
sec:envelope-consequence (r2755 CORRECTED THE SENTENCE AND NOT THE NUMBER THE SENTENCE DEFINES: ‘theta_D/theta_*‘ was corrected from $9.4\{}%$ to $8.2\{}%$ and ‘sec:envelope-consequence‘’s r, one paragraph later, IS that ratio and still read 1.093 — so the paper stated one ratio twice, differently, and the second is the one the prediction is made of. Corrected from three agreeing routes to $r=1.0816$: the ratio at $\{}ell_D$ moves 0.823 → 0.844, at $1.5\{}ell_D$ 0.645 → 0.682, $\{}ell_D(\{}rm CR)$ 1281 → 1294. **FIFTEEN receipts carried it — eight SILENTLY (exiting zero, six of them evaluating the envelope with the wrong value) and seven LOUDLY (failing every full run since r2755 — and they are the seven that PRODUCED the correction).** CONTROL: C10’s gate was built so the paper and the receipt ”cannot drift apart silently in either direction”, and it worked — they were consistent with each other and both wrong.). *Computes:* COMPUTES: the identity $r=\{}theta_D/\{}theta_*$ read from C10’s own assertion message; the corrected value from three routes and the four quantities that follow; the fifteen receipts split by failure mode and counted at the commits where they exist; the C41 double-allocation resolved as one rule at two states; and the register files deliberately left alone (21 checks) *Bound:* **bound: 1.0816 is NOT re-derived here** — it is read from ‘P15_damping_ratio_clean‘, ‘C46‘ and the corrected sentence, and checked for agreement. **Not claimed that the envelope is right**, only that it now runs on the ratio the paper’s own preceding paragraph derives. **The correction FAVOURS the construction (16% suppression at $\{}ell_D$ rather than 18%) and is flagged for it**; it would apply identically the other way. ‘PO-7‘ is ‘sec:refit-bound‘/‘sec:coherence‘ and is untouched. *Run:* `python3 receipts/L557_the_correction_stopped_at_the_sentence/R1_the_correction_stopped_at_the_sentence_and`

`P1_the_pin_test_run_the_spacing_follows_the_pin_so_the_ratio_does_not` [OK]
sec:tensions (THE PIN TEST, RUN — the runs the observer line’s container killed twice. **The peak spacing tracks the one fitted number PROPORTIONALLY** (‘LATARG‘ 280/301.6/320 → mean spacing 229.3/245.3/261.3), so spacing/ℓ_A = 0.8190/0.8134/0.8167 — **0.69% spread across a 14% pin range**, against the **13.4%** a constant-spacing arm would give: a factor of twenty, so the measurement DISCRIMINATES. ⇒ **The routed dichotomy is inverted: following the pin is exactly what makes the RATIO — which is what the deficit is — independent of the pin. THE DEFICIT SURVIVES THE FIT.** Also: ‘KCONT=1‘ at NK=320 returns the same four peaks, discharging the instrument’s own standing sampling caveat; and **ℓ_1 = 172 at all three pins**, so ℓ_1/ℓ_A is pin-dependent while the spacing ratio is not. LCDM control on the same grid: 0.9909, reproducing the sky to 6 in ℓ.). *Computes:* COMPUTES: five banked runs parsed from their own printed blocks; the spacing ratio and its spread; the CONSTANT-spacing alternative computed as the control and the discrimination factor between them; the KCONT identity and its sampling-guard margin; ℓ_1’s invariance and ℓ_1/ℓ_A’s spread;

and the LCDM arm checked against the sky before being used (21 checks) *Bound:* NOT-A-PAPER-CLAIM — **and the declaration is deliberate: this is a measurement on the instrument's own fitted parameter, delivered to a routed question, and whether it lands in 'sec:tensions' is the observer line's call under 'PO-7'.** A node that banked it into the paper on its own initiative would be taking a step toward the verdict the row protects. **bound: this reports a number and does not convert it into a verdict — 'PO-7' is protected.** Not that r2789's 258 was wrong (different grid; the control was re-run here rather than compared across grids). Not that peaks are known better than the ℓ-grid: 'LSTEP=8', ±4 per peak, ±8 per spacing — the invariance claim is 20× outside that and the individual spacings are not. Not that the deficit is explained, only that the fitted number does not produce it. *Run:* `python3 receipts/L562_the_pin_test/P1_the_pin_test_run_the_spacing_follows_the_pin_so_the_ratio_does_not.py`

P15R142 `P15_the_driving_is_bought_by_decay_during_oscillation` [OK]
sec:transmission (THE DRIVING SHIFT IS BOUGHT BY POTENTIAL DECAY OCCURRING WHILE A MODE OSCILLATES, so a mode whose oscillation begins after the potential has settled inherits the UNDRIVEN phase. ** Coupled photon/matter/potential solve on a matter-and-radiation background, with the potential closed by the ENERGY CONSTRAINT rather than evolved and the acoustic turnover taken at the first zero of the photon velocity that BEGINS A SEQUENCE SPACED BY pi – the free oscillator's own spacing, which the undriven gate validates at 1.0000 on both arms. ** SCOPE: the ASYMPTOTIC statement only, Q -¿ 1 at large k, which is what P15 and P07 assert; NOT the low-k values, and NOT a magnitude (neutrino free-streaming omitted, ˜15% low). A sign flip in the initial amplitude is a pi phase shift and moves WHICH ZERO IS FIRST by one half-period, so four initial signs agree to 0.012 at k=160). *Computes:* COMPUTES: a coupled photon/matter/potential solve on a matter-and-radiation background, the potential closed by the ENERGY CONSTRAINT rather than evolved; the UNDRIVEN gate validated at 1.0000 on both arms before use; the driven arm asserted to FALL toward 1 from above and to reach the free-oscillator value to 0.02 at large k; the control asserted well below 1 and flat in k to 0.10; the two shapes asserted qualitatively distinct by a factor of two in range; and the robustness leg showing a factor of two in the radiation budget barely moves it. Rerun r3537, ALL PASS *Bound:* SCOPE, and the receipt states it: the ASYMPTOTIC statement only, $Q\{}to1$ at large k, which is what 'P15' and 'P07' assert; **NOT the low-k values and NOT a magnitude** — neutrino free-streaming is omitted, some $15\{}%$ low *Run:* `python3 receipts/P15_CR_cosmology/P15_the_driving_is_bought_by_decay_during_oscillation.py`

P15R143 `N8_the_transmission_dichotomy_is_a_capacity_dichotomy` [OK]
sec:transmission (prop:transmission, rem:transmission-leg) (P15 proves a transmission dichotomy — a non-degenerate horizon (p=1) imprints a scale, a degenerate one (p=2) transmits — and rem:transmission-leg says "the leg multiplies the spectrum by a constant and the seam imprints nothing: neither carries a scale, and a spectrum can only be tilted by something that does". That is a CHANNEL claim, and "carries a scale" is what decides its capacity). *Computes:* fits the output tilt on four disjoint k-bands: p=2 returns the same tilt on every band (spread 1.7e-16) while p=1 spreads by 7.93, which IS the scale; the control puts a cutoff into the p=2 kernel by hand and the spread jumps to 1.91, so the test can fail; and the p=1 spread shrinks monotonically 30.2 -¿ 7.9 -¿ 2.3 as kappa rises, tracking the kernel's scale *Bound:* SUPPORTS P15 — transparent means the answer does not depend on where you look, and imprinting means it does. NOT a Bogoliubov calculation; no Hawking temperature claimed *Run:* `python3 receipts/P15_CR_cosmology/N8_the_transmission_dicho`

P3R12 `P03_acceleration_is_slice_curvature` [OK]
sec:curvature · rem:twocritical · the bend (on ANY member of the energy family (E cancels: (dr/dtau)ˆ2 = Eˆ2 - f, and E is a constant of the motion) dˆ2r/dtauˆ2 = -f'/2 = r*K_G identically, so THE SIGN OF THE SLICE'S GAUSSIAN CURVATURE IS THE SIGN OF THE COMOVING ACCELERATION – and the flat locus is the deceleration-to-acceleration turnover, which on Nariai is the seam and in standard terms is rho_m = 2 rho_Lambda (cschˆ2 w = 2 ¡=¿ sinh w = 1/sqrt2, the seam's phase). A recent cosmological epoch: 7.06 Gyr at H0=73, 7.65 at 67.4, preceding matter-Lambda equality [borrowed from P3 · P7 · P8]). *Computes:* the identity asserted; the K_G zero solved and matched to (M alphaˆ2)ˆ(1/3); cschˆ2 w = 2 ¡=¿ sinh w = 1/sqrt2 proved by algebra after simplify() failed on the closed forms; epochs at both H0 *Bound:* bound: identities on the Nariai E=1 worldline; no causal claim between seam and turnover – they are one locus; dating inherits H0 *Run:* `python3 receipts/P03_SdS_slicing/P03_acceleration_is_slice_curvature.py`

P15R35 `BRANCHPT_transmission_character` [OK]

rem:phase-open (BRANCHPT — the transmission character of the BRANCH POINT r=0, on its own terms. WHY (r2154). P15 l.525 says "The cosmogenesis branch point, BEING the degenerate Nariai horizon, is a faithful scale-free transmitter", and prop:transmission argues from the tortoise integral at a DOUBLE ROOT (p=2, kappa=0). **PART 2, from the receipt-vs-sentence audit: the PEAK-POSITION EXCLUSION, which is what P15 actually cites this file for and which the file did not compute** — the collapse leg's own conformal time gives eta_bp ~ 5e3-1e4 Mpc, so r_s^eff = r_s + eta_bp/sqrt3 = 3.0-5.9e3 Mpc, and reproducing l_A = 301.8 would demand D = 2.9-5.7e5 Mpc against the actual 1.4e4, a factor of **21-41**. *PART 1 shows the crossing ADDS no divergent phase; PART 2 shows an inherited phase cannot survive. The paper's sentence needs the second.* [borrowed from P15 (+P7)]). *Computes:* runs clean; registered from its own docstring and a live run *Bound:* description is the receipt's own wording, condensed; not independently re-derived here *Run:* `python3 receipts/P15_CR_cosmology/BRANCHPT_transmission_character.py`

`H1_the_low_multipole_deficit_is_two_effects_and_the_ladder_imprint_dies_where_the_transfer_is_narrow` [OK]

corpus integrity (**THE HARMONIC-ANALYSIS BAKE — second of the four fields 'L-272''s resurvey left outstanding, thrown r3166.** **BOUNCED, and largely:** the field's first question is why a closed-S^3 source is projected through FLAT spherical Bessel functions, and 'P15' answers it in its own text — the distance slicing is flat, so only the source modes carry the closed-S^3 quantization — while its measure $w_L=(L+1)/(L(L+2))$ is derived twice, as degeneracy over per-mode power and as $d\{}ln k_L/dL$, both agreeing to machine precision. **BIT:** the deficit reported as one geometric effect splits exactly into a **FLOOR** (modes below $L{=}2$ removed) and a **LADDER COARSENESS**. At $\{}ell=5$–6 the second contributes $+0.38$ against a floor of 0.27–0.53 — comparable, and in the opposite direction — and it is what sets the recovery multipole the paper quotes ($\{}ell=8$ with it, $\{}ell=10$ without). Under $\{}pm2\{}%$ in r_0 the floor moves $-2.4\{}%$ to $-6.2\{}%$ and the full result $+27.8\{}%$ to $-43.3\{}%$: **the location is the floor and is robust as claimed; the depth is the ladder and is volatile**, which gives the paper's own qualitative split a mechanism. **AND A SELF-WAIVED GATE BECOMES A BOUND:** 'P15' records that the ladder "samples the projection below the rate the instrument's own aliasing gate demands, and that gate waives itself on the claim that the ladder is physical." The imprint dies at $\{}ell\{}simeq k_2D_Ce^{3\{}sigma}$; to reach the first acoustic peak the transfer would need to draw power over a factor of nine in k. **Safe with a wide margin, by measurement.** [borrowed from —]). *Computes:* COMPUTES: the spherical-Bessel completeness identity $\{}sum_\{}ell(2\{}ell+1)j_\{}ell(x)^2=1$ to ten figures and the exact plateau $\{}int j_\{}ell^2 d\{}ln x=1/(2\{}ell(\{}ell+1))$ reproduced on the fixed grid to six, both **before anything is used**; the measure against $d\{}ln k_L/dL$ and against degeneracy-over-power at five L; the paper's own $D_C/r_0\{}to0$ limit; the floor/discreteness decomposition across $\{}ell=2$–12; each half's response to $\{}pm2\{}%$ in r_0; the recovery multipole with and without the discreteness; and the imprint against transfer width at four $\{}sigma$, with the scaling rule checked against all four rather than extrapolated (15 checks). *Bound:* NOT-A-PAPER-CLAIM — corpus integrity; no paper edited. **NOT claimed:** that the deficit is wrong — every number touched is reproduced or confirmed, the paper's own limit included; that these are predictions about the sky — the decomposition is the pure Sachs–Wolfe limit while the paper's depths come from a genuine Boltzmann transfer it says are milder, and the two are not compared; that the real transfer's width is measured — $\{}sigma$ is a Gaussian-in-$\{}ln k$ stand-in and measuring $\{}Delta_\{}ell(k)$ is the owed next step; that the aliasing gate should stop waiving — only that the waiver now has a margin; that the low-$\{}ell$ oscillation is derived rather than measured. *Run:* `python3 receipts/L274_the_harmonic_bake/H1_the_low_multipole_deficit_is_two_effects_and_the_ladder_imprint_`

Appendix L The Knowledge Ledgers

Each claim marked ᴸ in the text rests on a field bake or the figure–theorem bake recorded in the named ledger, which ships with this work and carries the probes, the receipts, and the three registers kept apart — what bit, what bounced, and where the boundary is. A ledger is working apparatus, not a publication, and is cited here rather than in the bibliography. This appendix is generated from the ledger index, not maintained by hand.

L9 `CONVEXITY_OPTIMISATION_LEDGER.md` [field bake]
The convexity / optimisation field-bake ledger — what bit, what bounced, and the boundary. One of the three fields listed but never thrown (the overnight order: convexity $\times 143$, constraint $\times 141$). 'OWED' 622

L23 `OPTICS_LENSING_LEDGER.md` [field bake]
observational optics and lensing against CR — confirmations, and the dimension clause they forced

L19 `SPECTRAL_THEORY_LEDGER.md` [field bake]
The spectral-theory field bake — what bit, what bounced, and the boundary. Tier B's largest never-thrown field ($\times 189$ on the reach measure), verified as NOT covered by the harmonic ledger, which mentions spectral, self-adjoint and deficiency zero times

L21 `INFORMATION_THEORY_LEDGER.md` [field bake]
The information-theory field-bake ledger — what bit, what bounced, and where the boundary is

L22 `NUMERICAL_ANALYSIS_LEDGER.md` [field bake]
The numerical-analysis field-bake ledger — what bit, what bounced, and where the boundary is

L14 `INTEGRABLE_SYSTEMS_LEDGER.md` [field bake]
The integrable-systems field-bake ledger — what bit, what bounced, and where the boundary is

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