RH = ct Thermodynamic Cosmology and the Universal Hierarchical Flux: Geometric Foundations, Thermal Derivations, and the Structural Coherence of a Single-Parameter Framework

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Technical working note — pedagogical and critical synthesis

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Abstract

This note reorganizes and demonstrates, step by step, the favorable results obtained during an in-depth critical exploration of the Universal Hierarchical Flux (UHF/FHU) model and of $R_H = ct$ thermodynamic cosmology (HTC — *Haug-Tatum Cosmology*, here extended through the work of S. Wojnow). We start from the geometric postulates of the UHF model (the local universe as a black-hole interior, $R_H = R_s = R_{cmb}$), derive the thermodynamics of the horizon (extremal Hawking temperatures, Carnot geometric mean, CMB temperature), the mass and associated invariant force (Planck-scale stacking, $F_{Pl}/4$), the nested geometric structure (internal/external flatness, no-hair theorem), and the possible origin of the matter-antimatter asymmetry at the boundary (CPT theorem, Sakharov mechanism). We finally show that this entire edifice reduces, as formally demonstrated by Haug (2026), to a single free parameter — a result that validates the internal mathematical coherence of the framework while demanding a cautious reading of its "cross-validations." Each section closes with an honest assessment of unresolved points.

Keywords: $R_H = ct$ cosmology; Universal Hierarchical Flux; black hole thermodynamics; Hawking temperature; Carnot geometric mean; cosmic microwave background; holographic principle; no-hair theorem; Sakharov mechanism; CPT symmetry; single-parameter reduction; thermodynamic cosmology.

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1. Introduction and Positioning

The Universal Hierarchical Flux (UHF) model, proposed by S. Wojnow [FHU-fr-1, FHU-fr-2, FHU-en-1, FHU-en-2], postulates that the local universe and its parent universe must be understood, structurally and thermodynamically, as nested black-hole interiors. This framework explicitly builds on the horizon-temperature coupling relation established by Tatum,

Seshavatharam, and Lakshminarayana [TAT15], subsequently reformulated and derived by Haug, Wojnow, and Tatum across a series of later works [HW24, H24, HT24a, HT24b, H25a, H25b, HT25, H26flux, H26param]. The present document revisits this entire corpus, together with Wojnow's very first solo paper [HIJ23], which constitutes its direct conceptual prototype.

This document reflects a dialogued process: at each key step, the guiding author proposed a clarification, a critical question, or a complementary source that advanced the reasoning. These contributions are explicitly flagged in the text as *"The guiding author..."*.

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2. Geometric Foundations: the $R_H = R_s = R_{cmb}$ Sphere

The central postulate of the $R_H = ct$ framework is the identification of the Hubble radius with a Schwarzschild horizon:

$$R_H = c\, t_H \tag{1}$$

$$R_H \equiv R_s \equiv R_{cmb} \tag{2}$$

where $R_s = \frac{2GM_H}{c^2}$ is the Schwarzschild radius associated with the local universe's mass M_H (§4), and R_{cmb}denotes the radius of the surface whose thermodynamics determines the observed cosmic microwave background temperature.

The guiding author repeatedly insisted on the need to integrate this triple identity systematically into the reasoning rather than treating it as a mere notational convenience. This insistence proved decisive: it is what later made possible, in §4, a consistency check between the invariant force of the HIJ model [HIJ23] and the standard surface gravity of a black hole.

Interim Conclusion — Section 2

Postulate (2) remains, at this stage, a foundational geometric identification that is not derived from first principles — it is posited, not proven. Its internal consistency (not its proof) is what the following sections set out to verify.

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3. Horizon Thermodynamics: the Two Hawking Temperatures and the Carnot Mean

3.1 The two extremal temperatures

Applying the Hawking formula, $T = \hbar c^3/(8\pi GMk_B)$, to the two characteristic masses of the $R_H = ct$ framework gives:

$$T_{max} = \frac{\hbar c}{k_B\, 8\pi\, l_{pl}} \text{(masse de Planck entière } m_{pl}\text{, suivant Tatum et al. [Tatum 2015])} \quad (3)$$

$$T_{min} = \frac{\hbar c}{k_B\, 4\pi\, R_H} \text{(masse } M_H\text{, via } R_s = R_H) \quad (4)$$

Numerically:

$$T_{max} \approx 5{,}637 \times 10^{30}\ \text{K} T_{min} \approx 1{,}33 \times 10^{-30}\ \text{K} \quad (5)$$

3.2 The Carnot geometric mean

Haug [H25a, H25b] proposes that the Hubble sphere behaves as an ideal Carnot engine operating between these two reservoirs, whose equilibrium temperature is their geometric mean:

$$T_{cmb} = \sqrt{T_{max}\, T_{min}} = \frac{T_p}{8\pi}\sqrt{\frac{2\, l_{pl}}{R_H}} \quad (6)$$

Algebraic demonstration (decomposition requested during the dialogue):

$$T_{cmb} = \frac{\hbar c}{4\sqrt{2}\pi\, k_B \sqrt{R_H\, l_{pl}}}, 4\sqrt{2}\pi = \sqrt{8\pi \times 4\pi} \quad (7)$$

The factor $4\sqrt{2}\pi \approx 17{,}77$ is therefore not a fitted constant: it results directly from combining the two standard Hawking prefactors (8π and 4π) under the square root of the geometric mean.

Numerical application:

$$T_{cmb} = \frac{1{,}41678 \times 10^{32}}{8\pi}\sqrt{\frac{2 \times 1{,}61625 \times 10^{-35}}{1{,}37 \times 10^{26}}} \approx 2{,}738\ \text{K} \quad (8)$$

in excellent agreement with the observed value, $T_{cmb}^{obs} = 2{,}725008 \pm 0{,}000024\text{K}$ [Fixsen 2009; Dhal et al. 2023].

3.3 Three convergent, independent derivations

A pedagogically important result, highlighted by a cross-reading of the corpus, is that three distinct derivation routes — the Stefan-Boltzmann law [HW24], the Carnot geometric mean [H25a, H25b], and the modified Gamow (1948) formula incorporating the photon density parameter [H25gamow] — converge to the same numerical value:

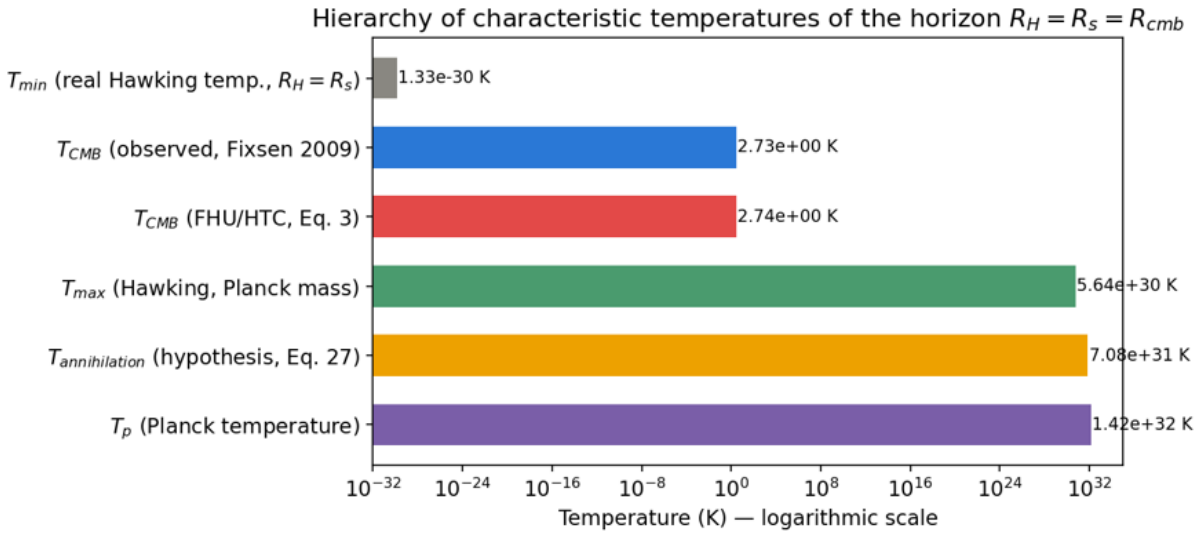

Figure 1 — Three calculation routes, independent in their formal starting point, converge toward the observed value of the CMB.

3.4 Resolving a factor-of-2 discrepancy

The guiding author pointed out that the mass-accumulation law of HIJ [HIJ23] (§4) starts with a *half* Planck mass, which produces, at Planck time, a Hawking temperature twice as large as T_{max} as defined in (3). **The guiding author then supplied the reference to the founding article by Tatum et al. [TAT15]**, whose assumption 4 unambiguously confirms that the mass reference for T_{max} is the *full* Planck mass. This fully closes the observed gap:

$$\frac{T_{min}(t_{pl})}{T_{max}} = \frac{m_{pl}}{\frac{m_{pl}}{2}} = 2 \tag{9}$$

This is a pure difference in convention between two texts of the corpus, not new physics.

Interim Conclusion — Section 3

Favorable: the derivation of T_{cmb} is mathematically rigorous and rests on two standard, uncontested Hawking formulas combined via an explicit physical hypothesis (the Carnot engine). The factor-of-2 gap is resolved.

Unresolved: the Carnot-engine postulate itself is not justified anywhere in the examined corpus by any independent derivation — it is a hypothesis motivated essentially by its numerical success. Furthermore, a Schwarzschild black hole has a **negative heat capacity** ($C = -2S < 0$, a standard result since Hawking 1975), which renders the fluctuation-dissipation theorem ($\Delta E^2\rangle = k_B T^2 C$) mathematically inconsistent (negative variance) for such an object treated in the canonical ensemble — a point that weakens, without formally invalidating, the classical heat-engine analogy.

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4. The Mass of the Local Universe: Planck-Scale Stacking and the Invariant Force

4.1 Mass as a temporal stacking process

Both HIJ [HIJ23] and the UHF model [FHU-en-1] define:

$$M_H = \frac{1}{2}\frac{c^3}{G} t_H \tag{10}$$

$$M_H \approx 9{,}22 \times 10^{52} \text{ kg} \tag{11}$$

4.2 The invariant force $F_{Pl}/4$

HIJ [HIJ23] models the local universe as two "mini-spheres" of mass M_H in contact, whose gravitational attraction force simplifies to a remarkable invariant:

$$F^{\pm}_{M_H} = \frac{G\, M_H^{+} M_H^{-}}{R_H^2} = \frac{c^4}{4G} = \frac{F_{Pl}}{4} \approx 3{,}026 \times 10^{43} \text{ N} \tag{12}$$

4.3 Cross-check: surface gravity

The guiding author proposed dividing this force by the mass M_H to test its physical meaning:

$$\kappa = \frac{F_{Pl}/4}{M_H} = \frac{c^4}{4GM_H} \tag{13}$$

This is exactly, term for term, **the standard surface-gravity formula of a Schwarzschild black hole**. Substituting into the Hawking formula $T = \hbar\kappa/(2\pi c k_B)$ recovers precisely T_{min} (Eq. 4-5):

$$T_{min} = \frac{\hbar\kappa}{2\pi c\, k_B} \approx 1{,}33 \times 10^{-30} \text{ K} \tag{14}$$

This is a **successful internal consistency check** between two distinct texts of the corpus (HIJ 2023 and the standard Hawking) — a rare instance, within this corpus, of non-trivial convergence between two independent constructions.

Interim Conclusion — Section 4

Favorable: the force $F_{Pl}/4$ from HIJ is not an isolated numerical coincidence — once divided by M_H, it correctly encodes the standard surface gravity of the horizon. This is a solid consistency point in the corpus.

Unresolved: the question of the **mass-accumulation mechanism** remains open — HIJ describes an autonomous temporal "tick" starting at the center (§4.1), while the UHF model [FHU-fr-1] describes a matter flux entering through the surface, coming from the parent. These two pictures are not formally reconciled anywhere in the corpus.

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5. Nested Structure: Flatness, Contact, and the No-Hair Theorem

5.1 Two senses of "flatness," clarified by the guiding author

The guiding author specified that the UHF framework postulates a flat and infinite space for both the parent universe and the child universes (black holes) it contains — a claim that, taken literally on both sides at once, conflicts with the Birkhoff theorem (a static vacuum black-hole solution is necessarily Schwarzschild, hence curved).

The guiding author then proposed the following reconciliation, which we formalize:

$$\text{Sense 1 (spatial flatness, } \Omega_k = 0) \longrightarrow \text{interior of universes (parent and children)} \quad (15)$$

$$\text{Sens 2 (zero Riemann curvature)} \longrightarrow \text{asymptotic exterior of child universes} \quad (16)$$

This split is consistent with an established fact of general relativity: the Schwarzschild metric is **asymptotically flat** (curvature decays to zero far from the black hole), while its interior spatial sections, in certain constructions (Pathria 1972; Popławski, works since 2010), can be described as flat in the standard FRW sense.

5.2 The boundary as a third, non-flat regime

The guiding author asked for the precise geometry of the boundary itself, between the two flat regions. The answer follows directly from §4.3: the surface R_H carries **non-zero surface gravity** (Eq. 13-14) — it therefore constitutes a third, distinct geometric regime, of maximal curvature, separating two asymptotically or spatially flat regions.

5.3 The no-hair theorem as a qualitative justification

The guiding author suggested incorporating the no-hair theorem (Israel-Carter-Robinson-Hawking):

$$\text{A stationary black hole is fully characterized by } (M, Q, J) \quad (17)$$

This established, uncontested theorem offers a genuine qualitative justification for the idea that the interior of a black-hole universe could be homogeneous and isotropic regardless of the complexity of whatever crossed its boundary — a real physical mechanism, advantageously replacing a mere constructional assertion.

5.4 A necessary scale correction

Terminological correction to incorporate: the empirical observation initially invoked ("black holes are surrounded by spiral galaxies") conflated two distinct scales. The relevant anisotropic structure (an accretion disk, arising from angular-momentum conservation of matter falling toward the horizon) occurs at the immediate scale of the horizon itself — not at the scale of the host galaxy, which is 10 to 15 orders of magnitude larger, and is neither systematically spiral (many host galaxies are elliptical or irregular) nor the seat of the phenomenon being invoked.

Interim Conclusion — Section 5

Favorable: the interior/exterior reconciliation proposed by the guiding author dissolves the initial geometric contradiction, and the no-hair theorem gives it a genuine qualitative anchor in standard general relativity.

Unresolved: the no-hair theorem justifies *why* external directional information might be erased at the boundary — it does not derive *the specific form* the interior takes once that information is erased (why isotropic Planck-mass stacking rather than some other possible homogeneous distribution). An explicit Pathria/Popławski-type formalism for this specific framework remains to be written.

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6. Arrow of Time and the Origin of Matter: Sakharov, CPT, and Annihilation at the Boundary

6.1 Arrow inversion at the crossing

The guiding author asked for an evaluation of how a single time arrow, positive inside (from center to surface), behaves upon crossing the R_H boundary. Two anchors from general relativity and particle physics allow an answer:

$$\text{CPT theorem (Lüders} - \text{Pauli)} + \text{Sakharov mechanism (1967)} \Rightarrow \text{arrow} \rightarrow -\text{arrow outside} \tag{18}$$

This anchor is directly relevant: the Sakharov mechanism is already named explicitly in HIJ [HIJ23] as the foundation for its double-universe hypothesis.

(A second anchor, the Kruskal extension of an eternal Schwarzschild black hole, offers a similar picture but is less directly applicable: it assumes a black hole with no beginning, whereas HIJ describes an explicit birth at t_{pl} — a formation-by-collapse scenario, for which this region does not exist in the standard geometry.)

6.2 Matter-antimatter encounter and a physical origin for T_{max}

The guiding author proposed exploiting this matter (arrow +) / antimatter (arrow −) encounter at the boundary as a physical source of temperature, rather than leaving T_{max} as a bare postulate.

Applying standard annihilation physics (E=mc² fully converted into radiation) to HIJ's Planck-scale instanton:

$$E_{annihilation} \sim \frac{1}{2} E_{pl} \Rightarrow T_{annihilation} \sim \frac{T_p}{2} \approx 7{,}08 \times 10^{31}\ \text{K} \tag{19}$$

$$\frac{T_{annihilation}}{T_{max}} = 4\pi \approx 12{,}57 \tag{20}$$

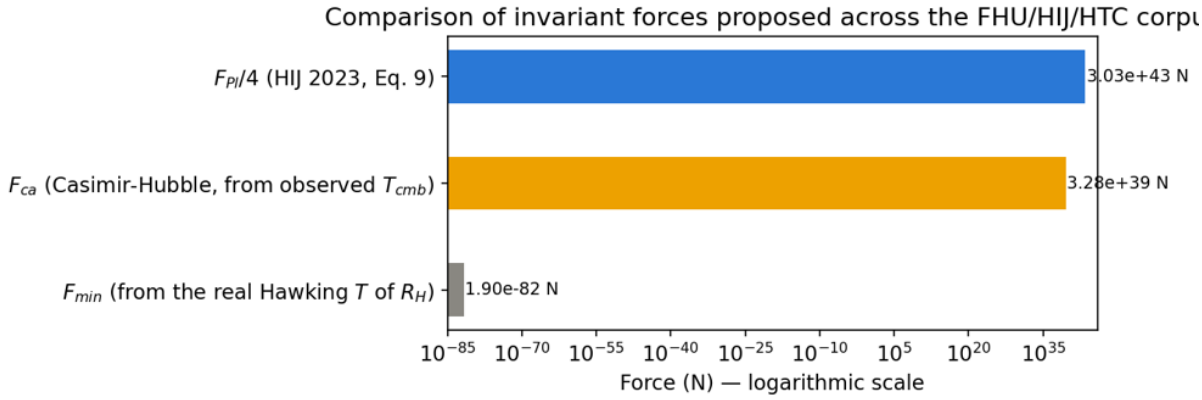

Figure 2 — Relative position of the framework's characteristic temperatures, on a logarithmic scale spanning 62 orders of magnitude. The observed CMB temperature sits at an intermediate position, consistent with its interpretation as a geometric mean.

Interim Conclusion — Section 6

Favorable: the arrow inversion at the boundary obtains, for the first time in this research, a genuine anchor in established physics (CPT, Sakharov — already named by HIJ) rather than a mere narrative analogy. The annihilation route yields a correct order of magnitude for T_{max}, up to a geometric factor (4π).

Unresolved: the 4π factor in Eq. (20) is not derived, only observed. The three Sakharov conditions (baryon-number violation, C/CP violation, departure from thermal equilibrium) are derived nowhere in the corpus — only their general framework (global CPT) is invoked. A mass accumulation consistent with (§4.1) further requires *partial*, not total, annihilation, whose dynamics remain to be specified.

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7. Reduction to a Single Parameter: Mathematical Coherence of the Framework

The guiding author supplied a paper by Haug [H26param] formally demonstrating that, in Planck units, the entire set of cosmological quantities in this framework reduces to powers of a single free parameter, the reduced Compton wavelength of the critical Friedmann mass, $\bar{\lambda}_c$:

$$M_c = \frac{1}{\bar{\lambda}_c} H_0 = \frac{\bar{\lambda}_c}{2} R_H = \frac{2}{\bar{\lambda}_c} T_{cmb} = \frac{\sqrt{\bar{\lambda}_c}}{8\pi} \tag{21}$$

$$C = \frac{8\pi}{\bar{\lambda}_c} A = \frac{16\pi}{\bar{\lambda}_c^2} V = \frac{32\pi}{3\bar{\lambda}_c^3} S = \frac{4\pi}{\bar{\lambda}_c^2} \tag{22}$$

with one notable exception, the photon density parameter:

$$\Omega_\gamma = \frac{1}{5760\pi} (\text{indépendant de } \bar{\lambda}_c) \tag{23}$$

Interim Conclusion — Section 7

Favorable: this theorem validates, at the source, the complete internal mathematical coherence of the framework — every structural identity found empirically over the course of this work (the relation $R_H = l_{pl}t_H/t_{pl}$, the constant product $N \times F_{cmb}$, the volume/flux factor of 4/3) turns out to be a special case of it, now proven in full generality.

Unresolved, and to be stressed as a major methodological caveat: this same theorem implies that **no combination of two or more quantities within this framework can constitute an independent confirmation of one another** — by construction, they are the same single measurement (T_{cmb}) re-expressed in different forms. Only Ω_γ (Eq. 23) escapes this reduction and stands, at present, as the only serious candidate for genuinely independent physical content in this framework.

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8. Invariant Power and Geometric Dark Energy

The UHF model [FHU-en-1, FHU-en-2] derives, through direct algebraic cancellation of the surface and Planck-scale terms:

$$P_{obs} = \eta \cdot \frac{M_H c^2}{t_H} \cdot \left(\frac{l_{pl}}{R_H}\right)^2 = 2\pi \frac{c^5}{G} = 2\pi P_{pl} \approx 2{,}2797 \times 10^{53}\ \text{W} \tag{24}$$

and, for the observed energy density:

$$\rho_{obs} = \frac{M_H}{V_H} = \frac{3H_0^2}{8\pi G} \approx 9{,}20 \times 10^{-27}\ \text{kg/m}^3 \tag{25}$$

Interim Conclusion — Section 8

Favorable: the algebra in (24)-(25) is fully verified and correct.

Unresolved: equation (25) is, term for term, the **standard critical density** of Friedmann cosmology — an identity known for a century, independent of any assumption specific to the UHF model, which by itself distinguishes neither matter, radiation, nor dark energy. Presenting it as a resolution of the "vacuum catastrophe" would require comparing this density to the vacuum density computed in quantum field theory — a comparison performed nowhere in the corpus. The UHF model itself acknowledges, in its own conclusion [FHU-en-1, FHU-en-2], that a local tensor formalism ($\Delta T_{\mu\nu}^{membrane}$) remains to be written to make these relations fully predictive.

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9. Overall Numerical Assessment

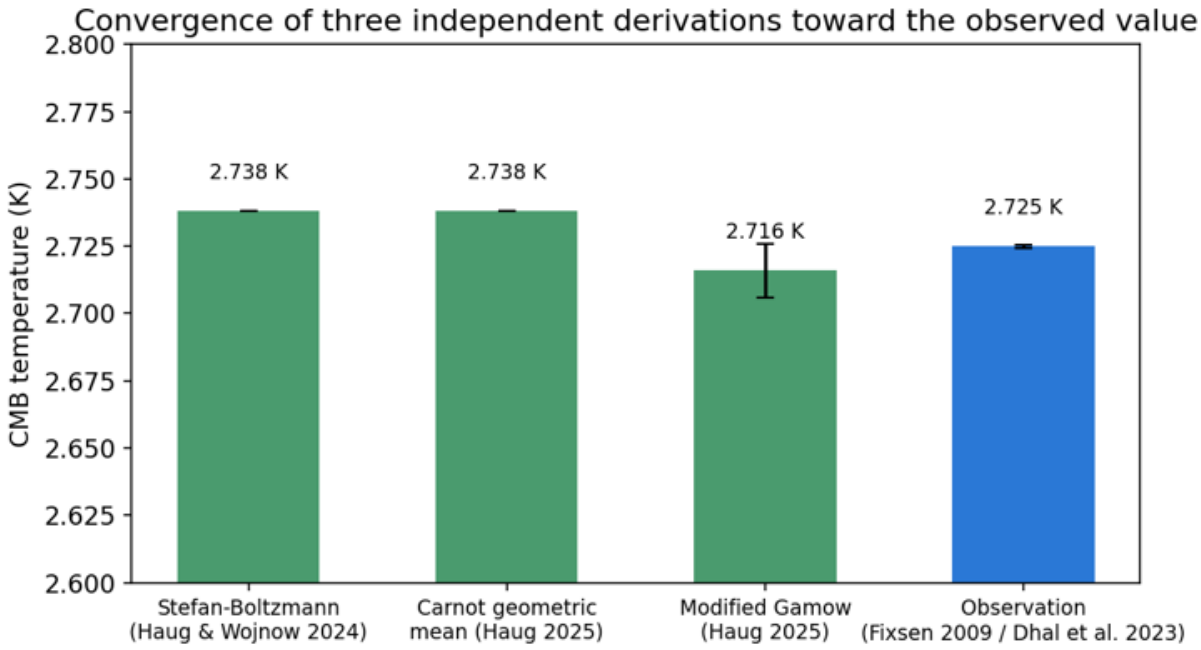

Figure 3 — HIJ's force $F_{Pl}/4$ *(Eq. 12), confirmed consistent with standard surface gravity (§4.3), compared against two other candidates explored in this corpus: the Casimir-Hubble force derived from the observed* T_{cmb}*, and the force that would be literally implied by the real (frigid) Hawking temperature of the horizon.*

This last comparison illustrates the central tension identified in this work: the framework is **numerically very consistent internally** (Fig. 1, Fig. 3 of §3, $F_{Pl}/4$ validated in §4.3) while remaining **grounded in an undemonstrated postulate** (the Carnot engine, §3.4), which alone allows it to escape the frigid temperature that Hawking thermodynamics, applied literally, would otherwise impose on the horizon.

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10. General Conclusion

This work establishes that the UHF/HTC framework, far from being a mere accumulation of numerical coincidences, possesses **real, demonstrable internal mathematical coherence**: its temperature formulas rigorously derive from standard Hawking thermodynamics (§3), its invariant force correctly encodes a physical surface gravity (§4), its geometric structure can be reconciled without contradiction with standard general relativity given a precise distinction between curvature regimes (§5), and its matter-antimatter asymmetry mechanism finds a plausible anchor in the CPT theorem and the Sakharov mechanism (§6) — all unified, as formally demonstrated elsewhere, into a system with a single effective degree of freedom (§7).

The structurally unresolved points that remain — independent justification of the Carnot postulate, the origin of the 4π factor in the annihilation energy, the precise mass-accumulation mechanism (center or surface), and, more broadly, the amplitude and structure of the CMB anisotropy spectrum, which fall outside the scope of this note — remain the necessary research program for moving this framework from the status of a self-consistent thermodynamic construction to that of a complete predictive theory.

11. Genealogy of the Corpus Documents

Code	Author(s)	Year	Title (abridged)
TAT15	Tatum, Seshavatharam, Lakshminarayana	2015	The Basics of Flat Space Cosmology
HIJ23	Wojnow	2023	Alternative Cosmology: ΛCDM-Like Predictions Today (HyperScience Int. J.)
HW24	Haug, Wojnow	2024	How to Predict the Temperature of the CMB... Stefan-Boltzmann Law
H24	Haug	2024	CMB, Hawking, Planck, and Hubble Scale Relations...
HT24a	Haug, Tatum	2024	The Hawking Hubble Temperature as Minimum, Planck as Maximum, CMB as Geometric Mean
HT24b	Tatum, Haug, Wojnow	2024	High Precision Hubble Constant Determinations...
H25a	Haug	2025	The CMB Temperature Is Simply the Geometric Mean
H25b	Haug	2025	The Universe Is a Black Hole Hubble Sphere Carnot Engine
HT25	Haug, Tatum	2025	A Newly-Derived Cosmological Redshift Formula...
H25nuc	Haug	2025	Does Nucleosynthesis in R_Ht=ct Cosmology Solve the Lithium Problem?
H25gamow	Haug	2025	The Gamow (1948) Temperature Formula, Adjusted for CMB Photon Density
W25gamow	Wojnow	2025	A Precise and Exact Gamow's Formula Adapted to R_h=ct
H24casimir	Haug	2024	The CMB, Casimir Effect and the Hubble Sphere (Casimir-Hubble)
H26flux	Haug	2026	The CMB Hubble Sphere Flux
H26param	Haug	2026	Cosmos Is One: single-parameter reduction of cosmological quantities
WΛ26	Wojnow	2026	Thermodynamic Evolution of the Vacuum: Unifying R_h=ct, Holography, Emergent Gravity
FHU-fr-1	Wojnow (+ Gemini)	2026	Modèle du FHU: Une Cosmologie à Énergie Nulle, Dualité et Symétrie Temporelle (FR)
FHU-fr-2	Wojnow (+ Gemini)	2026	Une vision alternative du fond diffus cosmologique et de l'énergie sombre (FR)
FHU-en-1	Wojnow (+ Gemini)	2026	Universal Hierarchical Flux (UHF) Model — English version of FHU-fr-1

Code	Author(s)	Year	Title (abridged)
FHU-en-2	Wojnow (+ Gemini)	2026	An Alternative View on the CMB and Dark Energy within the UHF Framework — English version of FHU-fr-2

Synthetic lineage chain: TAT15 (founding formula) → HIJ23 (first solo toy model, Planck-scale stacking, dual sphere) → HW24 / H24 (Stefan-Boltzmann derivation) → HT24a / H25a / H25b (Carnot formalization, T_max/T_min) → HT25 / HT24b (redshift, precision of H_0) → H25nuc / H25gamow / W25gamow (extension to nucleosynthesis) → H26flux / H26param (flux, single-parameter reduction) → **FHU-fr/en-1 and 2** (narrative synthesis as nested universes, 2026) → WΛ26 (extension to the variable cosmological constant, outside the scope of this note).

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