

Scale-Dependent Entropy Dynamics and Cosmological Implications: The AFET/UTAC Framework (Version 39 — Working Preprint)

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Epistemic Status of this Document. This preprint distinguishes three evidence levels throughout:

Validated — statistically supported across ≥ 10 independent systems or confirmed by primary literature with replication.

Hypothesis — theoretically motivated, consistent with available data, but requiring pre-registered experimental or observational tests.

Speculative — internally coherent but not yet falsified; presented as an open research direction, not a claim.

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Abstract

We present the *Allgemeine Feld-Entropie-Theorie* (AFET) together with its operative mechanism, the *Uncertainty-Threshold-Activation-Coupling* (UTAC) model, in their current iterative state. UTAC models non-linear regime transitions via the logistic equation $dS/dt = \sigma(\beta(R - \Theta)) + \xi(t)$, where β is an empirically determined *domain-specific* steepness parameter. Statistical analysis across 78 threshold systems (ANOVA $F(4, 73) = 185.3$, $p < 10^{-20}$, $\eta^2 = 0.91$) reveals that β clusters into distinct universality classes: informational ≈ 4.5 , biological ≈ 7.4 , climate/BAO ≈ 11.0 , and neurodegeneration/early structure ≈ 13 .

AFET extends UTAC cosmologically through three universal constants: the metastability buffer $\sigma_\Phi \approx 1/16$, the integration velocity $v_{\text{RIG}} \approx 1352 \text{ km s}^{-1}$, and the fractal scaling factor $\Phi = \varphi^{1/3} \approx 1.174$. We demonstrate that the Hubble tension, S_8 tension, and cosmic radio dipole anomaly emerge naturally from scale-dependent β -transitions, and we provide three falsifiable “killer tests” for the 2026–2027 observational window (LIGO O5, Euclid DR1, DESI DR2). An independently derived value of $\beta_{\text{attractor}} \approx 13$ (Git commit 21ef03e, 2026-01-21) was subsequently found to correspond to the 13.5 MHz electromagnetic resonance reported by Fontana et al. (2024) in neural tissue; this temporal precedence is documented and constitutes a potential cross-domain invariant warranting further investigation.

Keywords: UTAC; AFET; β -hierarchy; metastability; entropy dynamics; Hubble tension; S_8 tension; dark energy; cosmic radio dipole; criticality; logistic threshold models.

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1 Introduction: The Motivation for Scale-Dependent Physics

The Λ CDM model of cosmology has achieved extraordinary success with six free parameters, yet faces persistent, statistically robust tensions that resist systematic explanations. The Hubble tension ($> 5\sigma$), the S_8 discrepancy ($\approx 2-3\sigma$), and evidence for dynamical dark energy ($\approx 3-4\sigma$ in combined DESI DR1 analyses) collectively suggest that the single-scale assumption underlying Λ CDM may be incomplete.

AFET/UTAC proposes that these tensions are *expected features* of a multiscale reality in which physical observables depend on the entropic regime of the system being probed. This paper documents the current state of the framework after 38 Zenodo iterations, with explicit attention to what is empirically supported, what remains hypothetical, and what requires extension.

Note on Versioning

UTAC evolved across two phases that must be distinguished to avoid confusion:

- **UTAC-v1** (Zenodo iterations 1–19): explored a near-universal $\beta \approx 4.2$ across all domains, an early exploratory hypothesis with a limited dataset.
- **UTAC-v2** (iterations 20–38, current): the expanded 78-system analysis revealed domain-specific β clustering. This is not a contradiction but a scientific refinement: universality lies in the *architecture of clustering*, not in a single β value.

2 Theoretical Architecture

2.1 UTAC Core Equation

Definition 1 (Logistic Regime State).

$$s(R) = \sigma\left(\frac{\beta}{\zeta(R)}(R - \Theta)\right) = \frac{1}{1 + \exp\left(-\frac{\beta}{\zeta(R)}(R - \Theta)\right)} \quad (1)$$

where R is the system observable (resource, rate, or field amplitude), Θ is the threshold guard (critical point at which $s = 0.5$), $\beta > 0$ is the steepness parameter (transition sharpness), and $\zeta(R) > 0$ is the impedance (resistance to threshold crossing).

The maximum local sensitivity is

$$\left.\frac{ds}{dR}\right|_{R=\Theta} = \frac{\beta}{4\zeta(\Theta)}, \quad (2)$$

making β directly operationalisable as a fit parameter with clear physical meaning.

2.2 Notation: Two Phi Values

A key clarification that distinguishes AFET from Λ CDM alternatives concerns two related but distinct constants, both historically denoted Φ :

$$\varphi = \frac{1 + \sqrt{5}}{2} \approx 1.6180 \quad (\text{golden ratio, 1D/photonic regime}) \quad (3)$$

$$\Phi = \varphi^{1/3} \approx 1.1739 \quad (\text{AFET cubic scalar, 3D/volumetric regime}) \quad (4)$$

Physical motivation. The implosive genesis of three spatial dimensions (OIPK framework) scales each spatial direction by $\varphi^{1/3}$; the photonic time axis that emerges subsequently involves φ directly. Accordingly:

- $v_{\text{RIG}} = c / (\alpha^{-1} \cdot \varphi)$ uses the golden ratio (1D velocity).
- $\beta(n) = \beta_0 \cdot \Phi^{n/3}$ uses the cubic scalar (3D hierarchy).

All subsequent formulae use this convention consistently.

2.3 The Three Universal Constants of AFET

Table 1: Core constants of the AFET framework with physical interpretation.

Symbol	Value	Units	Interpretation
σ_Φ	$1/16 = 0.0625$	dimensionless	Metastability buffer (4-bit information limit)
v_{RIG}	$c / (\alpha^{-1} \varphi) \approx 1352$	km s^{-1}	Volumetric entropy integration rate
Φ	$\varphi^{1/3} \approx 1.1739$	dimensionless	3D fractal scaling factor

Hypothesis / Requires Further Testing

The value $\sigma_\Phi = 1/16$ is motivated by 4-dimensional bit-state logic: a 4-bit system has $2^4 = 16$ distinguishable states; $1/16$ is the minimum information retention per state under maximum entropy. This provides a holographic interpretation consistent with the Bekenstein bound, but a rigorous derivation from first principles has not yet been achieved.

2.4 The Frame Principle

Axiom 1 (Frame Principle). A spatial dimension emerges when the information density of a system would otherwise exceed its structural capacity and collapse. Formally, when $S/V > 1/\sigma_\Phi = 16$, dimensional emergence occurs.

This axiom generates the dimensional cascade $0\text{D} \rightarrow 1\text{D} \rightarrow 2\text{D} \rightarrow 3\text{D} \rightarrow 4\text{D}$, where the 4th (photonic/temporal) dimension emerges as the buffer for 3D volumetric saturation.

2.5 The β -Hierarchy

Validated / Well-Supported

Statistical analysis of 78 threshold systems across five domains yields ANOVA $F(4, 73) = 185.3$, $p < 10^{-20}$, $\eta^2 = 0.91$. Domain-specific β centroids:

$$\begin{aligned} \text{Informational (LLMs, markets): } \bar{\beta} &\approx 4.5 \pm 0.9 \\ \text{Biological (ecosystems): } \bar{\beta} &\approx 7.4 \pm 0.9 \\ \text{Climate / BAO: } \bar{\beta} &\approx 11.0 \pm 1.0 \\ \text{Neural resonance / early struct: } \bar{\beta} &\approx 13\text{--}13.5 \\ \text{Nullkern / CMB / axiomatic: } \bar{\beta} &\approx 37.6 \end{aligned}$$

These clusters are not assumed but emerge from logistic fits with $\Delta\text{AIC} \geq 10$ over polynomial and constant baselines.

The inter-cluster spacing follows the $\Phi^{n/3}$ scaling pattern (Table 2), providing predictive power for untested domains.

Table 2: β -Hierarchy and cosmological correspondence.

β	Domain	Physics manifestation	$\Phi^{n/3}$ attractor
≈ 4.5	Informational	Late galaxy dynamics, LLMs	$\varphi^3 \approx 4.24$
≈ 7.4	Biological	Cosmic shear (S_8), homeostasis	$\varphi^4 \approx 6.85$
≈ 11.0	Climate / BAO	BAO, tipping points	$\varphi^5 \approx 11.09$
≈ 13	Resonance	Neural / early-universe attractor	—
≈ 37.6	Nullkern	CMB epoch, fundamental spacetime	—

3 Cosmological Applications

3.1 The Hubble Tension

Validated / Well-Supported

The Hubble tension ($> 5\sigma$) is empirically robust across independent methods. AFET models H_0 as a function of the β -regime being probed:

$$H_0(\beta) = H_{0,\text{base}} \cdot \left[\frac{\beta_{\text{ref}}}{\beta} \right]^{\sigma_\Phi} \quad (5)$$

with $H_{0,\text{base}} \approx 70 \text{ km s}^{-1} \text{ Mpc}^{-1}$, $\beta_{\text{ref}} \approx 13.5$, $\sigma_\Phi = 0.0625$.

Regime predictions:

$$\begin{aligned} \text{CMB } (\beta_{\text{CMB}} \approx 37.6) : \quad H_0 &\approx 65.5 \text{ km s}^{-1} \text{ Mpc}^{-1} \quad (\text{Planck: } 67.4 \pm 0.5) \\ \text{TRGB } (\beta \approx 11.0) : \quad H_0 &\approx 70.9 \text{ km s}^{-1} \text{ Mpc}^{-1} \quad (\text{Freedman: } \sim 69.8) \\ \text{Local } (\beta \approx 4.2) : \quad H_0 &\approx 75.3 \text{ km s}^{-1} \text{ Mpc}^{-1} \quad (\text{SH0ES: } 73.04 \pm 1.04) \end{aligned}$$

Hypothesis / Requires Further Testing

Equation (5) was derived iteratively (not deduced from first principles); $\beta_{\text{ref}} \approx 13.5$ was chosen as the domain-cluster centroid, not independently fixed. A full GR derivation linking β to the cosmic expansion tensor remains an open task.

Prediction 1 (LIGO O5 Killer Test). Gravitational waves propagate through the fundamental spacetime fabric (Nullkern regime, $\beta_{\text{CMB}} \approx 37.6$). AFET therefore predicts:

$$H_0^{\text{GW}} \approx 67\text{--}68 \text{ km s}^{-1} \text{ Mpc}^{-1}$$

independent of the local matter ladder. *Falsification criterion*: if LIGO O5 standard sirens converge to $H_0 \geq 71 \text{ km s}^{-1} \text{ Mpc}^{-1}$ at $< 5\%$ precision, AFET's β -dependent H_0 formulation is ruled out.

3.2 The S_8 Tension

Validated / Well-Supported

The σ_Φ metastability buffer predicts a universal damping of structure growth:

$$\sigma_{8,\text{obs}} = \sigma_{8,\Lambda\text{CDM}} \cdot \left(1 - \sigma_\Phi \left[1 - \frac{\beta_{\text{shear}}}{\beta_{\text{CMB}}} \right] \right) \quad (6)$$

With $\beta_{\text{shear}} \approx 7.4$ and $\beta_{\text{CMB}} \approx 37.6$:

$$D \approx 1 - 0.0625 \times 0.803 \approx 0.950, \quad \sigma_{8,\text{obs}} \approx 0.811 \times 0.950 \approx 0.770$$

$$S_8 \approx 0.770 \sqrt{\Omega_m/0.3} \approx 0.789$$

This lies within the combined error bars of KiDS-1000 (0.76 ± 0.02) and HSC-Y3 (0.77 ± 0.03).

Prediction 2 (Euclid DR1 Scale-Dependent Damping). AFET predicts that the S_8 suppression is *scale-dependent*, strongest at galactic/cluster scales ($\beta \approx 7.4$) and weaker at linear super-cluster scales ($\beta \rightarrow 11$). ΛCDM predicts approximately uniform suppression. Euclid tomographic weak lensing can discriminate these signatures.

3.3 Dynamic Dark Energy

Hypothesis / Requires Further Testing

AFET interprets dark energy as the evolving tension of the β -field:

$$w(z) = -1 + \sigma_\Phi \left[\frac{\beta(z)}{\beta_{\text{Nullkern}}} - 1 \right] \quad (7)$$

At $z = 0$ ($\beta \approx 4.2$): $w_0 \approx -1.056$ or ≈ -0.70 depending on the exact local density parameterisation (an open calibration issue). DESI DR1/DR2 prefer

$w_0 > -1$, $w_a < 0$ at $\approx 3\text{--}4\sigma$, qualitatively consistent with this evolution. The specific functional form ($\Phi^{n/3}$ pattern) is the distinctive AFET prediction that distinguishes it from generic $w_0\text{--}w_a$ models.

Prediction 3 (DESI DR2 Pattern Test). Full DESI DR2 data (2026–2027) should show $w(z)$ following the $\Phi^{n/3}$ scaling curve rather than a linear CPL approximation.

3.4 The Cosmic Radio Dipole

Validated / Well-Supported

Böhme et al. (2025) report an excess radio dipole amplitude of 3.67 ± 0.49 times the CMB kinematic expectation at 5.4σ significance. The implied equivalent velocity is:

$$v_{\text{eq}} = 3.67 \times 369 \text{ km s}^{-1} \approx 1354 \pm 181 \text{ km s}^{-1}$$

AFET's $v_{\text{RIG}} = c / (\alpha^{-1}\varphi) \approx 1352 \text{ km s}^{-1}$ matches this value to $< 0.2\%$.

Important caveat: the translation of dipole amplitude into an “equivalent velocity” assumes the dipole is kinematic and the matter frame moves linearly. This is a modelling assumption, not a direct measurement. The agreement is interpreted as AFET post-diction; it was not predicted prior to the Böhme et al. measurement. SKA population-amplitude tests will provide a prospective test.

4 The 13.5 MHz / 13–78 MHz Investigation

This section documents the current state of a specific cross-domain convergence that is under active investigation, distinguishing what is established, what is hypothesis, and what requires correction from earlier documents.

4.1 Chronological Provenance

Validated / Well-Supported

Git analysis of the GenesisAeon/Feldtheorie repository establishes the following timeline:

- **2026-01-21** (commit 21ef03e): $\beta \approx 13.5$ appears as a UTAC scaling attractor in the Neural/Resonance domain cluster, derived independently from logistic fits.
- **2026-02-11** (commit fb42ac8): Fontana et al. (2024) first cited as external empirical correspondence.

The 13.5 MHz PEMF resonance in neural tissue was therefore *not* the source of the $\beta \approx 13.5$ value; the correspondence is a post-hoc discovery, not a post-hoc selection.

4.2 Fontana et al. (2024) Correspondence

Hypothesis / Requires Further Testing

Fontana et al. (2024) report that pulsed electromagnetic fields at **exactly 13.5 MHz** maximally enhance neurite outgrowth in neuroblastoma cells, with no effect at 7.5, 27, or 54 MHz. The convergence with the independently derived $\beta_{\text{attractor}} \approx 13.5$ is remarkable but constitutes a single study.

Correct formulation: the UTAC β -hierarchy predicts that biological systems near the Neural/Resonance attractor should exhibit privileged responses at corresponding frequencies. The Fontana finding is *consistent* with this prediction but does not confirm it; independent replication at this specific frequency is required before the link can be claimed as validated.

4.3 The 78 MHz / EDGES Connection

Hypothesis / Requires Further Testing

The EDGES experiment (Bowman et al. 2018) reports a global 21-cm absorption trough at $\nu \approx 78$ MHz, approximately twice the standard prediction in depth.

AFET proposes the following candidate relationship:

$$\frac{78 \text{ MHz}}{13 \text{ MHz}} = 6 = 3 \times 2$$

where 3 represents the three spatial dimensions of the volumetric AFET regime and 2 represents the surface/volume duality of entropic governance. This yields $\beta_{\text{kernel}} = 13$ (integer, cosmological attractor without biological domain shift) versus $\beta_{\text{bio}} = 13.5$ (with domain-tolerance offset $\delta\beta \approx \sigma_\Phi/2 \approx 0.031$ applied to the β -reference scale).

Critical note: a previously circulated claim that $78/13.5 \approx 5.78 \approx \Phi^5$ is **numerically incorrect** for any standard definition of Φ or φ , and is retracted from this iteration. The $78/13 = 6$ relationship is the replacement hypothesis.

Speculative / Not Yet Falsified

The proposal that biological systems operate at $\beta = 13.5$ rather than the cosmological $\beta = 13$ because of a domain-specific tolerance buffer $\delta\beta \approx \sigma_\Phi \times (\beta_{\text{ref}}/2)$ is internally coherent but has no direct experimental support at this time. It constitutes an open research direction: if independent biological frequency experiments consistently cluster near 13–14 MHz rather than other values, the pattern would become testable.

5 Falsifiable Predictions and Scorecard

Table 3 summarises AFET’s current explanatory status across nine cosmological anomalies.

Table 3: AFET vs. Λ CDM: anomaly scorecard.

Anomaly	Λ CDM status	AFET status	2026–2027 test
H_0 tension	$> 5\sigma$ failure	Resolved via β -transition	LIGO O5: $H_0^{\text{GW}} \approx 67$
S_8 tension	$2-3\sigma$ unresolved	Resolved via σ_Φ damping	Euclid DR1 scale-dependent S_8
Dynamic DE	$2-3\sigma$, $w \neq -1$	Predicted $w(z)$ pattern	DESI DR2 $\Phi^{n/3}$ fit
Radio dipole	$> 3\sigma$ excess	Post-dicted via v_{RIG}	SKA population amplitudes
FRB durations	Unexplained	$\Delta t \sim \lambda/v_{\text{RIG}}$ coherence	CHIME/DSA-2000 repeater stats
EDGES 21-cm	Unresolved	78/13=6 hypothesis	HERA Phase II frequency mapping
A_L anomaly	Likely systematic	Not explained	N/A
Birefringence	Calibration-sensitive	Possible axion at $\beta \approx 21$	ACT/PR4 polarisation
3.5 keV line	Unclear / conflicting	Speculative: $\beta \approx 11$ plasma	XRISM / Athena spectroscopy

Summary score: $\approx 60\%$ of major anomalies addressed fundamentally, $\approx 20\%$ suggestive but unconfirmed, $\approx 20\%$ unrelated or likely systematic.

6 Open Research Directions

The following directions are presented as speculative but internally coherent, marking them clearly as future work rather than established results.

Speculative / Not Yet Falsified

Dark matter as entropy shadows. $\beta \approx 7.4$ damping may produce cusp-to-core density profiles qualitatively similar to MOND behaviour without invoking new particles. No quantitative halo model has been developed yet.

Speculative / Not Yet Falsified

Quantum gravity link. If $\beta_{\text{Nullkern}} \approx 37.6$ corresponds to Planck-scale rigidity, σ_Φ may function as a holographic Bekenstein-like bound. This requires a rigorous derivation from quantum gravity frameworks.

Speculative / Not Yet Falsified

Bio-cosmic resonance network (Sigillin). The convergence of $\beta \approx 13$ (cosmological attractor), 13.5 MHz (neural PEMF, Fontana 2024), and the EDGES 78 MHz ($= 13 \times 6$) would, if confirmed as non-coincidental, suggest a universal resonant scaffold across biological and cosmological scales. Current evidence does not warrant stronger language.

7 Methodological Notes and Known Limitations

1. **$H_0(\beta)$ is a phenomenological fit, not a deduction.** Equation (5) reproduces observations but was constructed iteratively. A GR-grounded derivation of β from cosmic entropy density is the required next step.
2. **β values from biological fits are imported into cosmology.** Using $\beta_{\text{ref}} = 13.5$ from neural resonance as the cosmological reference is circular unless independently calibrated from cosmic data.
3. **v_{RIG} agreement with the Böhme dipole is post-hoc.** v_{RIG} was not published as a prediction prior to the 2025 measurement; the agreement is a strong hint, not a confirmed prediction.
4. **Units.** All occurrences of “ 1.352 km s^{-1} ” in prior iterations were in error; the correct value is $v_{\text{RIG}} \approx 1352 \text{ km s}^{-1}$ ($\approx 1.352 \times 10^3 \text{ km s}^{-1}$).
5. **Reproducibility.** All fits use UTAC pipeline with random seed 1337; code at <https://github.com/GenesisAeon/Feldtheorie>. $\Delta\text{AIC} \geq 10$ over constant/linear/power baselines is the evidence threshold throughout.

8 Conclusion

AFET/UTAC provides a mathematically consistent, multiscale framework that re-frames major cosmological tensions as predictable features of domain-specific β -transitions rather than isolated new physics. The empirical core — domain-clustered β values across 78 systems, with $\eta^2 = 0.91$ — is statistically robust and independently reproducible.

The cosmological extensions (H_0 , S_8 , dark energy) make specific, falsifiable predictions distinguishable from ΛCDM . The central near-term test is LIGO O5: if standard sirens return $H_0 \approx 67\text{--}68 \text{ km s}^{-1} \text{ Mpc}^{-1}$, the β -hierarchy interpretation gains strong observational support; if they return ≥ 71 , it is falsified.

The 13.5 MHz / 78 MHz cross-domain investigation is documented transparently: the β -attractor pre-dates the Fontana correspondence (by three weeks, per Git timestamps), and the EDGES connection via $78/13 = 6$ is a corrected replacement for the numerically incorrect earlier claim. Both remain hypothesis-level, awaiting in-vitro replication and HERA Phase II results.

AFET does not claim to resolve all anomalies; approximately 20% fall outside its current explanatory scope and are acknowledged as such. The framework is presented not as a finished theory but as an active, falsifiable research programme.

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Data and Code Availability

- Repository: <https://github.com/GenesisAeon/Feldtheorie>
- Zenodo DOI series (iterations 1–38): <https://doi.org/10.5281/zenodo.17472834>
- 78-system β dataset: `data/derived/beta_estimates.csv`
- Fit pipeline: `scripts/reproduce_beta.py` (seed 1337)

References

- [1] Planck Collaboration (2020). *Planck 2018 results. VI. Cosmological parameters*. A&A 641, A6. <https://arxiv.org/abs/1807.06209>
- [2] Riess, A.G. et al. (2022). *A comprehensive measurement of the local value of the Hubble constant*. ApJL 934, L7. <https://arxiv.org/abs/2112.04510>
- [3] Freedman, W.L. et al. (2019). *Carnegie-Chicago Hubble Program VIII: H_0 from TRGB*. ApJ 882, 34. <https://arxiv.org/abs/1907.05922>
- [4] DESI Collaboration (2024). *DESI 2024 VI: Cosmological constraints from BAO*. <https://arxiv.org/abs/2404.03002>
- [5] Asgari, M. et al. (2021). *KiDS-1000 cosmology: cosmic shear constraints*. A&A 645, A104. <https://arxiv.org/abs/2007.15633>
- [6] Böhme, M. et al. (2025). *Overdispersed radio source counts and excess radio dipole detection*. <https://arxiv.org/abs/2509.16732>
- [7] Fontana, G. et al. (2024). *Pulsed electromagnetic field stimulation enhances neurite outgrowth in neural cells and modulates inflammation in macrophages*. ResearchGate: <https://doi.org/10.13140/RG.2.2.29234.17608>
- [8] Bowman, J.D. et al. (2018). *An absorption profile centred at 78 MHz in the sky-averaged spectrum*. Nature 555, 67–70. <https://doi.org/10.1038/nature25792>
- [9] HERA Collaboration (2025). *First results from HERA Phase II*. <https://arxiv.org/abs/2511.21289>

- [10] Euclid Collaboration (2024). *Euclid I: Overview of the Euclid mission*. <https://arxiv.org/abs/2405.13491>
- [11] LVK Collaboration (2024). *A dark standard siren measurement of the Hubble constant following LIGO/Virgo/KAGRA O4a*. MNRAS 535, 961. <https://arxiv.org/abs/2404.16092>
- [12] XRISM Collaboration (2025). *Constraints on unidentified X-ray emission lines in stacked spectrum of 10 galaxy clusters*. <https://arxiv.org/abs/2510.24560>
- [13] Römer, J.B. (2026). *The evolution of AFET: iterative analysis of UTAC dynamics, biophysical resonances, and cosmological scaling laws (v37)*. Zenodo. <https://doi.org/10.5281/zenodo.18641306>