

# Ordered Patch Theory

## Appendix T-4: MDL / Parsimony Comparison

Anders Jarevåg

v2.0.0 — April 2, 2026 | DOI: 10.5281/zenodo.19300777

### **Original Task T-4: MDL / Parsimony Comparison Problem:**

The live preprint claims parsimony over standard physics by treating physical laws as macroscopic compression algorithms, but does not provide a formal MDL comparison. **Deliverable:** Comparative MDL analysis of OPT versus benchmark physics model classes under explicit coding conventions.

**Closure status: CLOSED (conditional on typicality and IC normalisation).** This appendix delivers the formal MDL evaluation required by T-4. Three benchmark model classes are fixed with explicit coding conventions. Four theorems and one conjecture are established: (T-4a) OPT’s selector rule has  $\mathcal{O}(1)$  description length; (T-4b) Solomonoff dominance bounds OPT’s log-loss from above; (Conjecture T-4c) the conjectured source of OPT’s structural advantage is initial-condition compression; (T-4d) OPT achieves a permanent constant-bit model complexity advantage over every computable benchmark; (T-4e) the finite- $T$  advantage is conditionally quantified. The closure rests on three load-bearing conditions: the typicality of the observer stream, the absorption of the Solomonoff normalisation penalty  $\log(1/\xi(\mathcal{O}))$ , and the state of  $K(\text{IC} \mid \text{SP}) > K_0$ .

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## §1. Fixing the MDL Coding Conventions

MDL comparisons are meaningless without explicit, fixed coding conventions. The preprint’s §5.1 notes this requirement but defers it. We fix conventions here following Rissanen (1978) [12] and the two-part MDL framework of Li & Vitányi (2008) [27].

### 1.1 The Two-Part Code Length

For a hypothesis class  $\mathcal{M}$  and observation sequence  $y_{1:T} \in \{0, 1\}^*$ , the two-part MDL code length is:

$$L_T(\mathcal{M}) = K(\mathcal{M}) + L(y_{1:T} | \mathcal{M}) \quad (\text{preprint §5.1, Eq. 13})$$

where  $K(\mathcal{M})$  is the prefix Kolmogorov complexity of the hypothesis — the length of the shortest self-delimiting program on a fixed universal Turing machine (UTM) that outputs a complete description of  $\mathcal{M}$  — and  $L(y_{1:T} | \mathcal{M})$  is the negative log-likelihood of the data under  $\mathcal{M}$ 's best predictive model:

$$L(y_{1:T} | \mathcal{M}) = -\log_2 P_{\mathcal{M}}(y_{1:T})$$

For deterministic theories (laws + IC uniquely determine observations),  $L(y_{1:T} | \mathcal{M}) = 0$  when  $y$  is consistent with the theory and  $L = \infty$  otherwise. All logarithms are base 2; all code lengths in bits.

## 1.2 The Universal Machine

We fix a single optimal UTM  $\mathcal{U}$  throughout. All Kolmogorov complexities are relative to  $\mathcal{U}$ ; results change by at most  $\mathcal{O}(1)$  bits under a different choice of UTM. The Solomonoff measure  $\xi$  is defined relative to  $\mathcal{U}$  (preprint Eq. 1). This fixes the convention for all subsequent comparisons.

## 1.3 Scope of $y_{1:T}$

We compare models on the domain each was designed to predict: the observer's conscious stream  $y_{1:T} = z_{0:T}$  (the sequence of compressed latent states,  $C_{\max}$  bits per second over  $T$  seconds). Standard physics is evaluated on the same domain by reducing its predictions to the observer-compatible stream via coarse-graining. Both theories are asked to account for exactly the same observations.

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## §2. Benchmark Model Classes

Three benchmark classes are fixed. Each is assigned an explicit  $K(\mathcal{M})$  estimate under our UTM convention. Precise numerical values are order-of-magnitude estimates; the structural results in §§3–7 depend only on the ordering, not the exact values.

### 2.1 $\mathcal{M}_1$ — Standard Model + General Relativity

The most predictively accurate physical theory currently available. Its description requires three components:

- **Mathematical structure  $K_{\text{struct}}$ :** the gauge group  $SU(3) \times SU(2) \times U(1)$ , Lorentz invariance, renormalisability, and GR diffeomorphism symmetry. Kolmogorov complexity:  $K_{\text{struct}} \approx 10^3$  bits.

- **Parameter values**  $K_{\text{param}}$ : 19 SM free parameters + 3 mixing angles + 1 CP phase +  $\Lambda + G + c \approx 25$  constants encoded to experimental precision ( $\sim 30$  bits each):  $K_{\text{param}} \approx 750$  bits.
- **Initial conditions**  $K_{\text{IC}}$ : under the inflationary paradigm,  $K_{\text{IC}}^{\text{inf}} \approx 200\text{--}400$  bits. Note: We do not score Penrose’s  $10^{123}$  thermodynamic entropy bound here because it measures macroscopic phase-space volume ( $S$ ), not specific algorithmic Kolmogorov complexity ( $K$ ). The specific microstate may be highly compressible. We rely exclusively on the honest inflationary bounds.

$$K(\mathcal{M}_1) = K_{\text{struct}} + K_{\text{param}} \approx 1750 \text{ bits}$$

$$K(\text{IC} \mid \mathcal{M}_1) \approx 300 \text{ bits (inflationary)}$$

## 2.2 $\mathcal{M}_2$ — Generic Renormalisable QFT

The class of all renormalisable quantum field theories in  $\leq 4$  spacetime dimensions. This class contains  $\mathcal{M}_1$  as one member. Because gauge group and particle content must also be specified:

$$K(\mathcal{M}_2) \gg K(\mathcal{M}_1) \gg 1750 \text{ bits}$$

$\mathcal{M}_2$  is included as the foil for OPT’s claim that laws are selected, not enumerated. While the MDL comparison with  $\mathcal{M}_2$  is trivially won by any finite sub-class (including  $\mathcal{M}_1$ ) because  $K(\mathcal{M}_2)$  is unbounded, its inclusion serves formally to demonstrate the infinite scale of the parameter selection problem that the Stability Filter natively collapses.

## 2.3 $\mathcal{M}_3$ — Boltzmann Brain / Thermal Fluctuation

Standard physics with maximally simple initial conditions: a thermal (maximum-entropy) state at the Planck scale. Laws are identical to  $\mathcal{M}_1$ ; initial conditions are trivially simple:

$$K(\mathcal{M}_3) \approx K(\mathcal{M}_1) \approx 1750 \text{ bits}, \quad K(\text{IC} \mid \mathcal{M}_3) \approx 10 \text{ bits}$$

However, the log-likelihood of observing an ordered conscious stream  $y_{1:T}$  under  $\mathcal{M}_3$  is astronomically small:  $L(y_{1:T} \mid \mathcal{M}_3) \approx K(y_{1:T}) \gg T \cdot C_{\text{max}}$ .  $\mathcal{M}_3$  thus has negligible IC cost but a catastrophic likelihood cost, and is included to show that OPT’s MDL advantage is not achieved by the same trick.

### §3. OPT’s Code Length — Theorem T-4a

The MDL code length for OPT decomposes as:

$$L_T(\text{OPT}) = K(\xi, \text{Filter}) + L(y_{1:T} \mid \xi, \text{Filter}) = K_0 + \left(-\log \xi^{\text{Filter}}(y_{1:T})\right)$$

where  $\xi^{\text{Filter}}$  is the Solomonoff measure  $\xi$  conditioned on the observer-compatible class  $\mathcal{O}$  (streams satisfying  $R_{\text{req}} \leq B_{\text{max}}$ ), and  $K_0 = K(\xi, \text{Filter})$  is the description length of the selector rule.

**Theorem T-4a (Meta-Rule Complexity Bound).**  $K(\xi, \text{Filter}) = K_0 = \mathcal{O}(1)$  bits. Specifically:

$$K_0 \leq K(\mathcal{U}) + K(C_{\text{max}}) + K(\Delta t) + c$$

where  $K(\mathcal{U})$  is the complexity of the UTM,  $K(C_{\text{max}}) = \mathcal{O}(\log C_{\text{max}})$  bits encodes the bandwidth threshold to experimental precision,  $K(\Delta t) = \mathcal{O}(\log \Delta t)$  encodes the update window, and  $c$  is a small universal constant.

**Proof.** The Solomonoff measure  $\xi$  is uniquely determined by the fixed UTM  $\mathcal{U}$ , so  $K(\xi \mid \mathcal{U}) = \mathcal{O}(1)$ . The Stability Filter requires two parameters:  $C_{\text{max}}$  and  $\Delta t$ , each measured to  $\sim 4$  significant figures, so  $K(C_{\text{max}}, \Delta t) \leq 2 \times (4 \times \log_2 10) \approx 26$  bits. The condition  $R_{\text{req}} \leq B_{\text{max}}$  is a single inequality in fixed notation:  $\sim 10$  bits. Total:  $K_0 \leq K(\mathcal{U}) + 36$  bits.

To absorb  $K(\mathcal{U})$  fairly, we must assume an “epistemically neutral” UTM — meaning a reference machine whose built-in instruction set encodes no physical theory preferentially (i.e. a basic combinator or Brainfuck-equivalent geometry, completely agnostic to physics). Under such an unbiased machine, maintaining  $K(\xi, \text{Filter}) \approx 36$  bits while standardizing  $K(\mathcal{M}_1) \approx 1750$  bits is valid. We acknowledge this specifically leaves the absolute bit-count vulnerable to an  $\mathcal{O}(1)$  constant scaling if the UTM is changed, meaning the 36 vs 1750 calculation is inherently relative. The structurally honest mathematical statement here is the rank ordering ( $K_0 \ll K(\mathcal{M}_1)$ ), asserting a robust structural advantage independent of the precise numeric constant. ■

**Comparison:** Excluding the shared UTM overhead,  $K_0 \approx 36$  bits vs.  $K(\mathcal{M}_1) \approx 1750$  bits. The OPT selector rule is shorter than the Standard Model description by  $K(\mathcal{M}_1) - K_0 \approx 1714$  bits. This is the structural parsimony advantage claimed in §5 of the preprint — now with an explicit bit count.

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### §4. The Solomonoff Dominance Bound — Theorem T-4b

**Theorem T-4b (Solomonoff Dominance Bound).** For any computable physics measure  $\nu$  (including  $\mathcal{M}_1, \mathcal{M}_2, \mathcal{M}_3$ ) with  $K(\nu) < \infty$ , and for any data

stream  $y_{1:T}$ :

$$L_T(\text{OPT}) \leq L_T(\nu) + K'_0$$

where  $K'_0 = K_0 + \log(1/\xi(\mathcal{O}))$ . This represents the base rule complexity plus the necessary algorithmic normalization penalty incurred by conditioning the universal measure upon the observer class  $\mathcal{O}$ .

**Proof.** From the definition of the Solomonoff measure (preprint Eq. 1), with  $w_\nu \asymp 2^{-K(\nu)}$ :

$$\xi(y_{1:T}) \geq w_\nu \cdot \nu(y_{1:T}) \geq 2^{-K(\nu)} \cdot \nu(y_{1:T})$$

Taking negative logarithms:

$$-\log \xi(y_{1:T}) \leq -\log \nu(y_{1:T}) + K(\nu)$$

When transitioning from the universal measure  $\xi$  to the restricted filter  $\xi^{\text{Filter}}$ , we pay the normalisation cost  $-\log \xi^{\text{Filter}}(y) = -\log \xi(y) + \log(1/\xi(\mathcal{O}))$ . Substituting into  $L_T(\text{OPT})$ :

$$L_T(\text{OPT}) = K_0 - \log \xi^{\text{Filter}}(y_{1:T}) \leq K_0 + \log(1/\xi(\mathcal{O})) + K(\nu) - \log \nu(y_{1:T}) = K'_0 + L_T(\nu) \quad \blacksquare$$

**Important caveat.** Theorem T-4b does not show that OPT outperforms SP. It shows that OPT cannot do worse than any benchmark by more than  $K'_0$  bits. We absorb  $\log(1/\xi(\mathcal{O}))$  into  $K_0$  hereafter by assuming the class of observer sequences bounds cleanly relative to structural UTM constants, but note this normalisation gap as a formal vulnerability.

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## §5. The Initial Conditions Compression — Theorem T-4c

The structural source of OPT's MDL advantage is the compression of initial conditions. In standard physics, the laws and the initial conditions are separate objects that must both be described. In OPT, the initial conditions are absorbed into the prior: the Solomonoff measure already assigns highest weight to the simplest observer-compatible streams, making a separate IC specification redundant.

## 5.1 The IC Redundancy Argument

Under standard physics ( $\mathcal{M}_1$ ), the full MDL code for a deterministic theory is:

$$L_T(\text{SP}) = K_{\text{laws}} + K(\text{IC} \mid \text{laws}) + 0 \quad [\text{deterministic: } -\log P = 0 \text{ if consistent}]$$

The IC term  $K(\text{IC} \mid \text{laws})$  is the description length of the specific initial conditions *given* the laws — it is not derivable from the laws themselves. This is the locus of fine-tuning.

Under OPT, the two-part code is:

$$L_T(\text{OPT}) = K_0 + \left(-\log \xi^{\text{Filter}}(y_{1:T})\right)$$

The term  $-\log \xi^{\text{Filter}}(y_{1:T})$  encodes the specific stream given the meta-rule. The Solomonoff prior already incorporates a universal model of physics:  $-\log \xi(y) \approx K(y)$ . The OPT encoding never needs to separately pay for the IC.

**Conjecture T-4c (IC Compression Heuristic Bound).** Define the IC compression advantage:

$$\Delta_{\text{IC}} = K(\text{IC} \mid \text{SP laws}) - K(\text{IC} \mid \text{OPT})$$

We argue the following heuristic bound:

$$\boxed{L_T(\text{OPT}) \leq L_T(\text{SP}) - \Delta_{\text{IC}} + K_0 + \mathcal{O}(1)}$$

where  $K(\text{IC} \mid \text{OPT}) := K(\text{IC} \mid \xi, \text{Filter}, \text{codec})$  is the residual description length of the initial conditions given OPT's full model.  $\Delta_{\text{IC}} \geq 0$ , with equality iff the Stability Filter provides no additional compression of the IC beyond what the laws already give.

**Argument.** Starting from the full two-part code for SP and applying Solomonoff dominance (absorbing the normalisation constants into an  $\mathcal{O}(1)$  UTM bounding term):

$$L_T(\text{OPT}) \leq K_0 + K(\text{laws}) + K(\text{IC} \mid \text{laws}) - \log P_{\text{SP}}(y) + \mathcal{O}(1)$$

Rearranging and substituting  $L_T(\text{SP}) = K_{\text{laws}} + K(\text{IC} \mid \text{laws})$  (deterministic theory):

$$L_T(\text{OPT}) \leq L_T(\text{SP}) + K_0 + \mathcal{O}(1)$$

Within OPT,  $-\log \xi^{\text{Filter}}(y_{1:T})$  need not individually encode IC: the Filter selects from the Solomonoff prior, which compresses IC inherently via length weightings. AIT subadditivity guarantees  $K(\text{IC} \mid x, f(x)) \leq K(\text{IC} \mid x) + \mathcal{O}(1)$ . If we postulate that the OPT selection rule bounds as a tighter descriptive string than simply declaring the raw laws (which is the core wager of the framework, not a mathematical derivative proof), then the residual encoded  $K(\text{IC} \mid \text{OPT})$  cannot exceed  $K(\text{IC} \mid \text{laws})$  significantly. Yielding heuristically  $\Delta_{\text{IC}} \geq 0$ .

By substitution:  $L_T(\text{OPT}) \leq L_T(\text{SP}) - \Delta_{\text{IC}} + K_0 + \mathcal{O}(1)$ . ■

**Remark.** We hypothesize the anthropic compression  $K(\text{IC} \mid \text{OPT}) \approx 0$  operates in the limit where the Stability Filter is highly constraining, mapping mathematically to uniquely observer-compatible states. This is a motivated physical proposition rather than an algorithmically proven uniqueness bound.

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## §6. Constant-Bit Model Complexity Advantage — Theorem T-4d

**Theorem T-4d (Permanent Constant-Bit MDL Advantage — Conditional on Typicality).** For every fixed, non-trivial computable physics model  $\nu$  with  $K_0 < K(\nu) < \infty$ , the OPT formulation achieves a fixed, permanent model complexity advantage specifically for any  $y_{1:T} \in \mathcal{O}$  that is also  $\nu$ -typical. As the sequence length  $T \rightarrow \infty$ , the total code length difference is structurally bound:

$$L_T(\text{OPT}) - L_T(\nu) \rightarrow K_0 - K(\nu)$$

**Proof.** From T-4b,  $L_T(\text{OPT}) \leq K'_0 - \log \xi^{\text{Filter}}(y_{1:T})$ . For any computable  $\nu$ , Solomonoff's theorem guarantees that  $\xi$  converges to  $\nu$  exactly on  $\nu$ -typical sequences: measuring as  $\nu$ -almost-all  $y_{1:\infty}$ . Note the profound formal tension here: the Stability Filter isolates streams evaluating strictly as low-entropy and structured natively mapping them structurally *atypical* compared to standard unconstrained maximum-entropy  $\nu$ -measure streams. Unless the filtered observer class  $\mathcal{O}$  and the  $\nu$ -typical class possess demonstrable non-trivial mathematical overlap, the Solomonoff convergence limit cannot be natively leveraged. Consequently, this theorem applies conditionally if and only if the specific filtered observer stream remains  $\nu$ -typical under the specific benchmark laws (leaving the set of such theoretically compliant intersecting streams formally uncharacterised):

$$-\frac{1}{T} \log \xi(y_{1:T}) \rightarrow H(\nu) \quad \text{as } T \rightarrow \infty$$

where  $H(\nu)$  is the entropy rate of  $\nu$ . Similarly,  $-\frac{1}{T} \log \nu(y_{1:T}) \rightarrow H(\nu)$ . Asymptotically, the per-bit log-loss log-likelihood terms converge and equate, meaning the remaining total code length advantage isolates purely to the model description length:

$$[L_T(\text{OPT}) - L_T(\nu)] \rightarrow K_0 - K(\nu) < 0 \quad [\text{since } K_0 \approx 36 \text{ vs } K(\nu) \sim 1750]$$

Note: While the *total* code length maintains this permanent fixed-bit advantage, the *per-bit* advantage ( $\frac{K_0 - K(\nu)}{T}$ ) actively shrinks to zero. This does not represent an asymptotically continually growing advantage via data accumulation, but rather a permanent rigid structural offset. ■

**Numerical estimate for  $\mathcal{M}_1$ :**  $K(\mathcal{M}_1) - K_0 \approx 1714$  bits. Once the log-loss likelihoods converge over adequate  $\nu$ -typical observation windows, OPT maintains a permanent mathematical total encoding superiority of roughly 1714 bits.

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## §7. The Finite- $T$ Conditional Advantage — Theorem T-4e

For streams of finite length, the MDL comparison requires the IC compression advantage of T-4c to exceed the  $K_0$  overhead.

**Theorem T-4e (Finite- $T$  Conditional MDL Advantage).** OPT achieves a strict finite- $T$  MDL advantage over  $\mathcal{M}_1$  — that is,  $L_T(\text{OPT}) < L_T(\mathcal{M}_1)$  — if and only if the following condition holds:

$$K(\text{IC} \mid \text{SP laws}) > K_0 + \log \left( \frac{1}{\xi(\mathcal{O})} \right) + \left[ -\log \xi^{\text{Filter}}(y_{1:T}) - (-\log P_{\text{SP}}(y_{1:T})) \right]$$

The RHS bracket is the log-likelihood deficit of OPT relative to SP on the specific stream  $y_{1:T}$ . The condition is satisfied whenever the IC description cost exceeds the combined overhead of the meta-rule and OPT's prediction deficit on this stream.

**Proof.** Direct manipulation of the two-part code lengths:

$$\begin{aligned} L_T(\text{OPT}) &< L_T(\text{SP}) \\ \iff K_0 + \log \left( \frac{1}{\xi(\mathcal{O})} \right) - \log \xi^{\text{Filter}}(y) &< K_{\text{laws}} + K(\text{IC} \mid \text{laws}) - \log P_{\text{SP}}(y) \\ \iff K(\text{IC} \mid \text{laws}) - K_0 > \log \left( \frac{1}{\xi(\mathcal{O})} \right) &+ \left[ -\log \xi^{\text{Filter}}(y) - (-\log P_{\text{SP}}(y)) \right] + [K_{\text{laws}} - K_{\text{laws}}] \end{aligned}$$

Rearranging ( $K_{\text{laws}}$  cancels on both sides) gives the stated condition directly. ■

## 7.1 Evaluating the Condition for Standard Cosmology

Under the inflationary encoding (the most favourable case for SP):

- $K(\text{IC} \mid \text{SP laws}) \approx 300$  bits (inflationary parameters + e-fold count + reheating)
- $K_0 \approx 36$  bits (T-4a)
- The log-likelihood deficit: We functionally hypothesize that OPT, equipped with the  $R_{T,h}(D)$  codec limits mapped in T-1, achieves at least as robust a point-wise log-likelihood as standard physics on an observer-compatible stream. Note that Solomonoff bounds strictly yield dominance over expected sums, not definitive point-wise bounds on specific singular streams; so  $\left[-\log \xi^{\text{Filter}}(y) - (-\log P_{\text{SP}}(y))\right] \leq 0$  represents an empirical structural expectation rather than an algorithmic guarantee.

Therefore the condition reduces to  $K(\text{IC} \mid \text{SP laws}) > K_0$ , i.e.,  $300 > 36$ . This holds by a substantial structural margin. The condition fails only if IC costs fewer than  $\sim 36$  bits — i.e., if the specific IC of our universe is structurally derivable from the SP laws alone generating fewer than 36 residual bits. No current cosmological model achieves this.

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## §8. The Comparative MDL Table

| Model                            | $K(\mathcal{M})$<br>(bits) | $K(\text{IC} \mid \mathcal{M})$<br>(bits)                      | $-\log P(y \mid \mathcal{M})$                     | $L_T$ total                       | MDL rank                       |
|----------------------------------|----------------------------|--|---|-----------------------------------|--------------------------------|
| $\mathcal{M}_1$ — SM + GR        | $\sim 1750$                | $\sim 300$ (inflationary)                                      | $\sim 0$ (deterministic)                          | $\sim 2050$                       | 2nd (inflationary)             |
| $\mathcal{M}_3$ — Boltzmann      | $\sim 1750$                | $\sim 10$  | $\gg 0$ (rare stream)                             | $\gg 1760$                        | Last (catastrophic likelihood) |
| $\mathcal{M}_{\text{OPT}}$ — OPT | $\sim 36$                  | $\sim 0$ ( <b>conditional via highly constrained Filter)</b> ) | $\sim 0^*$ ( <b>deterministic codec approx)</b> ) | $\sim 36$ ( <b>conditional)</b> ) | <b>1st (conditional)</b>       |

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\* Under the explicit codec identification of §9.2, OPT's active data term reduces to  $-\log P_{K_\theta}(y) = -\log P_{\text{SP}}(y) = 0$  once  $K_\theta$  is identified with the SP codec.

## §9. Limits of the Comparison

### 9.1 $K(y \mid \text{Filter})$ is Not Computable

The OPT code length  $K_0 + K(y \mid \text{Filter}) = K_0 - \log \xi^{\text{Filter}}(y)$  contains a term that is not computable in the Turing sense (the halting problem prevents computing  $\xi$  exactly). In practice, OPT’s predictions must be approximated by a finite codec  $K_\theta$  — which is standard physics. This means that for *predictive* purposes, OPT reduces to the best computable codec available. The MDL advantage of OPT over SP is therefore a *structural* advantage (in the description of the selector rule) rather than an *operational* advantage in making novel predictions.

This is not a flaw — it is the correct formal content of the preprint’s claim: “OPT shifts part of the explanatory burden from law-enumeration to law-selection.” The shift is real and formally quantified ( $\approx 1700$  bits for the selector rule vs.  $\mathcal{M}_1$ ), but it does not generate new predictive content over and above what the codec already provides.

### 9.2 The Codec Identification Problem

The OPT codec  $K_\theta$  is the specific computable measure from  $\mathcal{M}$  that the Stability Filter selects. T-4 does not determine which measure this is — that identification requires T-5 (constants recovery) and the full physical unification programme. Until  $K_\theta$  is explicitly identified with SM + GR, the MDL comparison is conditional on this identification. The formal bound  $L_T(\text{OPT}) \leq L_T(\text{SP}) + K_0$  guarantees that OPT cannot do worse than SP, but does not guarantee it does better in finite time unless the IC condition of T-4e is met — which it is, under standard cosmological assumptions.

**Constraint from P-2.** Appendix P-2 (Hilbert Space Embedding via Quantum Error Correction) establishes that, under local noise, the codec must satisfy QECC structure — its internal representation must constitute a quantum error-correcting code with specific parameters  $(n, k, d)$ . This narrows the codec identification problem:  $K_\theta$  is no longer an arbitrary computable measure, but one whose predictive states carry the error-correcting geometry of a Hilbert space. This constraint is upstream of T-5’s constants recovery programme and may provide additional selection criteria for identifying  $K_\theta$  with the Standard Model.

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## §10. Closure Summary

### T-4 Deliverables — Confirmed Closed (with Normalisation & Typicality Conditions)

1. **Coding conventions fixed (§1).** Two-part MDL, prefix Kolmogorov complexity relative to an inclusive fixed UTM, mapping the data domain functionally onto the conscious stream  $y_{1:T} = z_{0:T}$ .
2. **Benchmark classes fixed (§2).** Evaluates  $\mathcal{M}_1$  (SM+GR) against trivial

boundaries like  $\mathcal{M}_2$  (exploding generative scope parameter selection) and  $\mathcal{M}_3$  (Boltzmann likelihood collapse).

3. **T-4a (Meta-rule complexity).**  $K(\xi, \text{Filter}) = K_0 \approx 36$  bits inclusive of relative UTM offsets.
4. **T-4b (Solomonoff bounded).**  $L_T(\text{OPT}) \leq L_T(\nu) + K_0 + \log(1/\xi(\mathcal{O}))$ . Defines the algorithmic normalisation penalty parameter explicitly.
5. **Conjecture T-4c (IC Compression Heuristic Bound).** Structural initial-condition redundancy is the conjectured engine of compression:  $\Delta_{\text{IC}} = K(\text{IC} \mid \text{SP}) - K(\text{IC} \mid \text{OPT}) \geq 0$ , though mapping uniqueness conditionally. This serves as a heuristic bound, not a formally proved theorem.
6. **T-4d (Constant-Bit Model Advantage).** Conditionally bounds the limit behavior: for computable benchmarks whose  $\nu$ -typical class overlaps non-trivially with  $\mathcal{O}$ , OPT secures a permanent numerical complexity advantage ( $\sim -1714$  bits), though its infinite per-bit density scales to zero.
7. **T-4e (Finite- $T$  advantage — conditional).** OPT beats  $\mathcal{M}_1$  numerically at finite  $T$  identically when empirical point-wise losses don't overturn the core  $K(\text{IC} \mid \text{SP}) > K_0$  structural boundary ( $300 > 36$ ). Focuses vulnerability squarely on algorithmic point-wise dominance assumptions.

#### Falsification conditions for the MDL claim

- A derivation of the cosmological initial conditions from SP laws alone in fewer than  $\sim 36$  bits — showing  $K(\text{IC} \mid \text{SP laws}) < K_0$ .
- A demonstration that the Stability Filter's restriction to observer-compatible streams does not compress IC — i.e.,  $K(\text{IC} \mid \xi, \text{Filter}) = K(\text{IC} \mid \text{laws})$ , giving  $\Delta_{\text{IC}} = 0$ .
- An explicit computable codec  $K_\theta$  for OPT that is demonstrably less accurate than SM+GR on observer streams, making the log-likelihood deficit exceed the IC compression gain.

#### Downstream dependencies

- **T-5 (Constants Recovery)** is the essential next step: once the codec  $K_\theta$  is identified with SM+GR laws via T-1/T-2/T-3, the MDL comparison becomes fully explicit and the conditional in T-4e becomes a concrete inequality between known quantities.
- **Preprint §5.2 update:** the phrase “Whether this meta-rule yields an actual MDL advantage... is an open comparative question” can now be updated to: “Theorem T-4d establishes a conditional asymptotic advantage (for observer streams that are also  $\nu$ -typical under the benchmark physics, a set currently uncharacterised); Theorem T-4e establishes a conditional finite- $T$  advantage; see Appendix T-4.”

*This appendix is maintained as part of the OPT project repository alongside theoretical\_roadmap.pdf. References: Rissanen (1978) [12], Li & Vitányi (2008) [27], Solomonoff (1964) [11], Penrose (2004).*