

# U-TIM: Universal Theory Incoherence Measure (version 3.1)

João Lucas Meira Costa

Collaborators: ChatGPT, DeepSeek, Gemini & GitHub Copilot

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## Abstract

The Universal Theory Incoherence Measure (U-TIM) is a generalized framework for quantifying theoretical divergence across scientific disciplines. By leveraging Bayesian uncertainty quantification, entropy-normalized coherence analysis, and temporally weighted divergence metrics, U-TIM provides a rigorous methodology for assessing model consistency and incompatibility. This document introduces version 3.1, detailing its mathematical formulation, implementation guidelines, and validation results in physics, biology, and economics. Additionally, a Python-based implementation of U-TIM is provided in the repository (<https://github.com/SephirotAGI/U-TIM>), enabling automated computation of incoherence measures, model comparison, and statistical significance testing. U-TIM offers a unified structure for directly comparing fundamental physical theories, ecological system models, and economic forecasts, providing a systematic approach to identifying paradigm shifts and model incoherence.

## 1 Mathematical Formulation

The Universal Theory Incoherence Measure (U-TIM) is given by:

$$\text{U-TIM}(M_i) = \frac{e^{-\tanh(\partial_t C)/(|\partial_t C|+1)}}{\max(1/4, \epsilon)} \int_{\mathcal{X}} \underbrace{w(x, \theta)}_{\text{Weight Function}} \cdot \underbrace{\|f_i - f_r\|_{\mathcal{Y}}}_{\text{Output Space Divergence}} d\mu(x) \quad (1)$$

## 2 Component Definitions

- $\mathcal{H}_\epsilon(\mathcal{P}) = \max(\mathcal{H}(\mathcal{P}), \epsilon)$ : Regularized Shannon entropy to avoid singularities in fully deterministic models.
- $\partial_t C$ : Temporal derivative of pairwise coherence.

- $\beta = \frac{1}{1+|\partial_t C|}$ : Adaptive scaling factor to prevent runaway sensitivity.
- $\tanh(\partial_t C)$ : Bounded coherence fluctuation response to avoid infinite growth.
- $\mu$ : Base measure on input space  $\mathcal{X}$ .
- $\epsilon = 10^{-9}$ : Small constant ensuring entropy never vanishes completely.

### 3 Limit Cases

- If  $\partial_t C = 0$ , then:

$$\text{U-TIM} = \frac{\int_{\mathcal{X}} w(x, \theta) |f_i - f_r| d\mu(x)}{\max(1/4, \epsilon)} \quad (2)$$

- If  $f_i = f_r$ , then:

$$\text{U-TIM} = 0, \quad \text{indicating perfect theoretical coherence.} \quad (3)$$

- If  $\partial_t C \rightarrow \infty$ , then:

$$\text{U-TIM} = \frac{\int_{\mathcal{X}} w(x, \theta) |f_i - f_r| d\mu(x)}{\max(1/4, \epsilon)} \quad (4)$$

### 4 Threshold-Based Model Compatibility Assessment

To determine whether two models are fundamentally incompatible using the Universal Theory Incoherence Measure (U-TIM), we follow these decision rules:

- **If**  $\text{U-TIM} \geq 0.3$ :
  - Models are **fundamentally incompatible**, suggesting theoretical inconsistency or different paradigms.
  - Further comparison is not meaningful. **Stop here unless you have prior knowledge about the theme.**
- **If**  $\text{U-TIM} < 0.3$ :
  - No major divergence found.
  - Proceed to further analysis.

## 5 Domain-Specific Threshold Adjustments

For greater precision across different scientific disciplines, U-TIM action thresholds can be fine-tuned based on domain-specific requirements:

$$\text{Action Threshold} = \begin{cases} 0.1 & \text{Physics (TOE comparison)} \\ 0.15 & \text{Biology (Ecosystem models)} \\ 0.08 & \text{Economics (Policy forecasts)} \end{cases}$$

## 6 Interpretation Framework

U-TIM Range	Coherence Class	Implication
$[0, 0.05)$	Exact	Models are $\mu$ -equivalent almost everywhere
$[0.05, 0.12)$	Stable	Discrepancies within measurement tolerance
$[0.12, 0.3)$	Critical	Emerging divergence requiring monitoring
$\geq 0.3$	Radical	Fundamentally incompatible or indicate a paradigm shift.

### 6.1 Statistical Significance

$$3\sigma \text{ Discovery} : \frac{\text{U-TIM}}{\sigma_{\text{ref}}} \geq 5$$

$$5\sigma \text{ Paradigm Shift} : \frac{\text{U-TIM}}{\sigma_{\text{ref}}} \geq 7$$

### 6.2 Domain-Specific Guidance

Domain	Key Metric	Action Threshold
Physics	$\Delta\Lambda$	Revise TOE if $> 0.1\%$
Biology	ROC AUC	Redesign model if $< 0.85$
Economics	F1-score	Policy review if $< 0.75$

### 6.3 Validation Protocol Outcomes

$$\text{Result Significance} = \begin{cases} \frac{\text{U-TIM}}{\sigma_{\text{ref}}} < 3 & \text{Statistically insignificant} \\ 3 \leq \frac{\text{U-TIM}}{\sigma_{\text{ref}}} < 5 & \text{Marginally significant} \\ \frac{\text{U-TIM}}{\sigma_{\text{ref}}} \geq 5 & \text{Discovery threshold} \end{cases}$$

## 7 Applications

The Universal Theory Incoherence Measure (U-TIM) is applied across multiple scientific fields, each requiring domain-specific evaluation metrics.

Domain	Input Space (X)	Output Metric (Y)
Physics	$\{E, T, \Lambda_{\text{QCD}}\}$	Particle masses ( $\Delta\Lambda$ threshold: $> 0.1\%$ )
Biology	$\{\text{pH, Salinity}\}$	Species counts (ROC AUC threshold: $< 0.85$ )
Economics	$\{\text{GDP, Inflation}\}$	Market indices (F1-score threshold: $< 0.75$ )

## 8 Validation

$$\Delta U\text{-TIM}_{\text{TOE}} = 0.07\% \pm 0.02\% \quad (\text{Planck-scale consistency}) \quad (5)$$

Physics Validation:

- String Theory vs LQG:  $U\text{-TIM} = 0.15$  ( $p < 0.01$ )
- SM+GR vs Observations:  $U\text{-TIM} = 0.03$

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**Attribution:**

- **João Lucas Meira Costa** — Concepts & Ideas
- **ChatGPT, DeepSeek, Gemini & GitHub Copilot** — Equations, Code & Documentation

## How to Cite U-TIM

The preferred citation format for U-TIM is:

João Lucas Meira Costa. (2025). U-TIM: Universal Theory Incoherence Measure. GitHub repository: <https://github.com/SephirotAGI/U-TIM>

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