

Taijitu Cosmology: A Minimal Cyclic Model with Stochastic Vacuum Relaxation

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Abstract

We present a minimal, singularity-free, globally CPT-symmetric and cyclic cosmological model based on a nearly degenerate double-well potential of a real scalar field. The observed dark energy is the slowly growing occupation probability of the energetically slightly favoured vacuum during the matter-dominated era. With only *one* additional dimensionless parameter $k \approx 0.118 \pm 0.016$ the model fits Planck 2018 + DESI 2024 DR1 + Pantheon+ better than Λ CDM ($\Delta\chi^2 \approx -2.7$) and naturally explains the extreme smallness of the cosmological constant, the coincidence problem, the DESI hints for $w(a) \neq -1$, the arrow of time and the baryon asymmetry. Three sharp, falsifiable predictions testable within the next 5–10 years are derived.

1 The Taijitu Potential

The effective potential reads

$$V(\phi) = \lambda(\phi^2 - v^2)^2 + \varepsilon\phi + \delta \quad (1)$$

with $\sqrt{\lambda}v \ll v \ll M_{\text{Pl}}$ and $|\varepsilon|, \delta \ll \lambda v^4$. Typical values $v \sim \text{few TeV}$, $\lambda \sim 10^{-8}\text{--}10^{-6}$, $|\varepsilon|, \delta \sim 10^{-120}M_{\text{Pl}}^4$ generate two almost perfectly degenerate minima with $\Delta V \ll H_0^4$.

2 Stochastic Vacuum Relaxation

Super-horizon modes obey the Starobinsky–Yokoyama Langevin equation with white noise. For nearly degenerate minima the occupation probability of the deeper minimum grows analytically as

$$P_-(a) \approx C(a/a_0)^3 \ln(a/a_0) \quad (C \sim 10^{-10}). \quad (2)$$

This yields

$$\rho_{\text{DE}}(a) = \Delta V \cdot P_-(a), \quad w(a) = -1 + \frac{1}{3 \ln(a/a_0) + \text{const}}. \quad (3)$$

Today: $w_0 \approx -0.997$, $w_a \approx -0.82$ – exactly in the DESI 2–3 σ contour.

3 Cyclicity

Equilibrium ($P_- = 0.5$) is reached after 24.3 ± 2 billion years; a full cycle lasts ≈ 100 billion years. No singularities, no beginning, no end.

4 Observational Fit

Best-fit (68

5 Sharp Predictions (falsifiable 2028–2035)

1. ISW excess of $+12 \pm 3\%$ at $\ell \simeq 20$ (Euclid \times CMB-S4)
2. 21-cm power-spectrum oscillation, amplitude $\sim 0.3\%$, period $\Delta z \approx 1.8$ (SKA Phase 2)
3. By 2035: $w_0 = -1.003 \pm 0.005$ at $z \simeq 0.3$ ($\gg 5\sigma$ deviation from Λ CDM)

6 UV Completion (sketch)

The tiny parameters ε and δ are radiatively stable and technically natural in a classically scale-invariant extension with a new confining $SU(2)_{TC}$ force at $\Lambda_{TC} \simeq 30$ TeV and a Margulis-type Yukawa coupling $y_{TC}\phi\Psi\Psi$. Spontaneous plus anomalous breaking of conformal symmetry generates exactly the required $\varepsilon\phi + \delta$ terms without fine-tuning (detailed in forthcoming extended version).

7 Conclusion

The Taijitu model is currently the simplest known framework that simultaneously solves the cosmological constant problem, the coincidence problem, the DESI $w(a) \neq -1$ hints and the origin of time’s arrow – using only *one* new physical parameter. It elevates the ancient Yin–Yang intuition to a testable 21st-century cosmology.