

# 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  $\Lambda$ 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  $v \sim \text{few TeV}$ ,  $\lambda \sim 10^{-8} - 10^{-6}$ ,  $|\varepsilon|, \delta \sim 10^{-120} M_{\text{Pl}}^4$  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  $2-3\sigma$  contour.

## 3 Cyclicity

Equilibrium ( $P_- = 0.5$ ) is reached after  $24.3 \pm 2$  billion years; a full cycle lasts  $\approx 100$  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  $\Lambda$ CDM)

## 6 UV Completion (sketch)

The tiny parameters  $\varepsilon$  and  $\delta$  are radiatively stable and technically natural in a classically scale-invariant extension with a new confining  $SU(2)_{\text{TC}}$  force at  $\Lambda_{\text{TC}} \simeq 30$  TeV and a Margulis-type Yukawa coupling  $y_{\text{TC}}\phi\Psi\Psi$ . 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.