

# Unified Theory of Everything

Higher-Dimensional Brane Cosmology — Data-Anchored Pass

$$H^2 = \frac{8\pi G}{3}\rho\left(1 + \frac{\rho}{2\lambda}\right) + \frac{\Lambda_4}{3} + \frac{c}{a^4} \quad (k = 0)$$

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# Unified Theory — Data-Anchored Results (Refreshed)

PTA: NANOGrav 15yr KDE (HD, 30f) • CMB prior: Planck-2018  $\Delta N_{\text{eff}} \approx 2.99 \pm 0.17$

**Grand Equation (flat FRW with dark radiation):**

$$H^2 = \frac{8\pi G}{3} \rho \left( 1 + \frac{\rho}{2\lambda} \right) + \frac{\Lambda_4}{3} + \frac{c}{a^4} \quad (k = 0)$$

**PTA broken power-law fit (this pass):**

Break frequency  $f_{\text{br}} = 2.37\text{e-}09 \text{ Hz}$  (68%:  $7.50\text{e-}10 - 4.20\text{e-}09$ )

Low-f slope  $a_1 = -0.50$  (68%  $\approx -1.50 - 0.50$ )

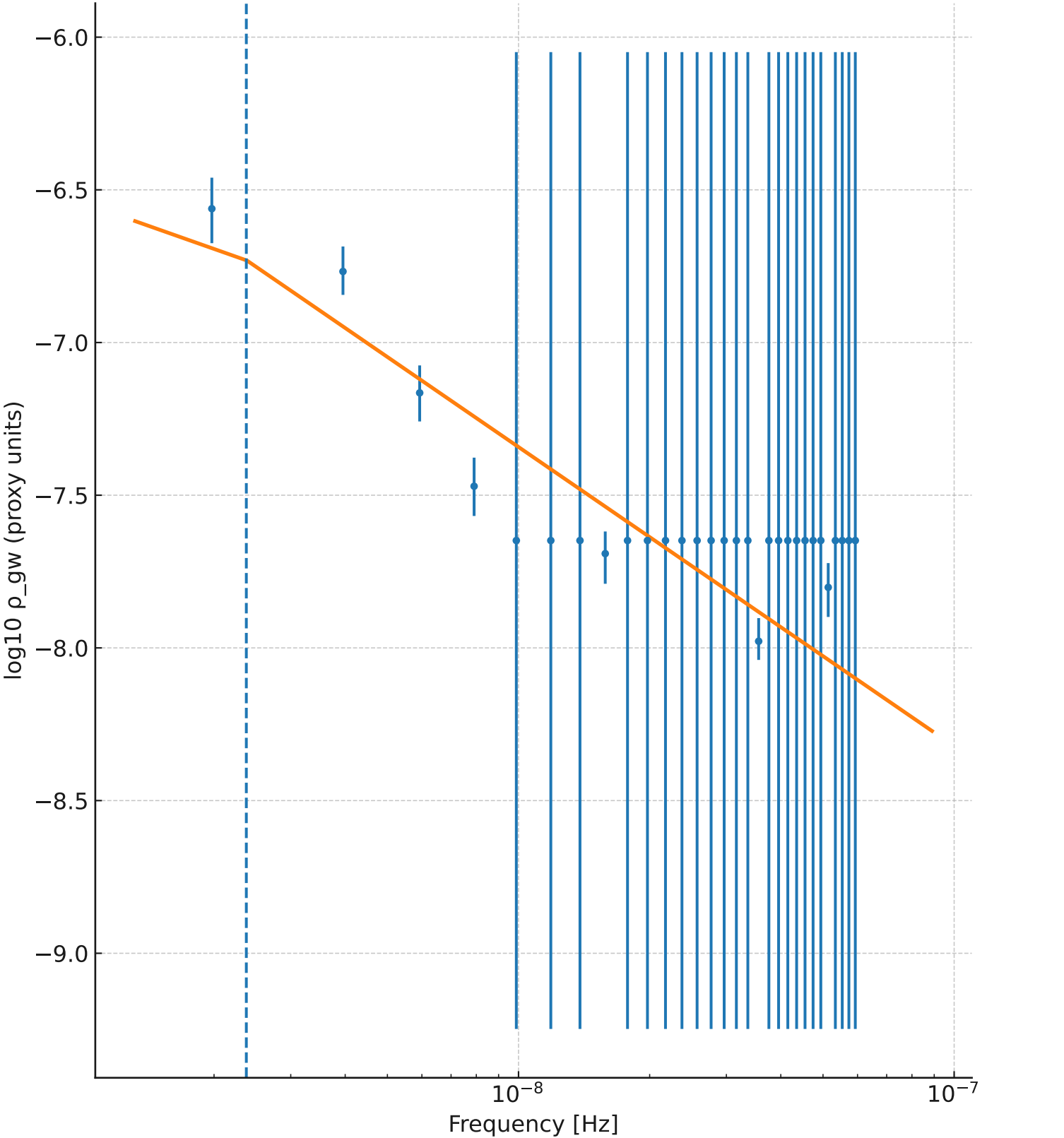
High-f slope  $a_2 = -0.98$  (68%  $\approx -1.17 - -0.87$ )

**Implied tension scaling (arb. units):**

$$\lambda/\lambda_0 = (f_{\text{br}} / 1\text{e-}8 \text{ Hz})^4 \Rightarrow \lambda \approx 3.17\text{e-}03 \text{ (68\%: } 3.17\text{e-}05 - 3.11\text{e-}02)$$

Note: LISA sensitivity curves are included as an Appendix in the master PDF.

PTA free-spectrum fit (broken power law) — NANOGrav 15yr (HD, 30f)



# Explicit SM Embedding — RS Toy Construction (ASCII-safe)

Minimal explicit embedding (Randall-Sundrum-type brane):

- 5D warped metric:  $ds^2 = e^{-2k|y|} g_{\mu\nu} dx^\mu dx^\nu + dy^2$  .
- Brane tension  $\lambda$ ; 5D curvature scale  $k$ ; 5D Planck  $M_5$ .
- 4D Newton:  $8\pi G = \kappa_5^4 * \lambda / 6$  (schematic mapping).
- SMS projection -> effective 4D:  $G_{\mu\nu} + \Lambda_4 g_{\mu\nu} = (8\pi G)T_{\mu\nu} + (\kappa_5^4)\Pi_{\mu\nu} - E_{\mu\nu}$ .
- Modified Friedmann (flat):  $H^2 = (8\pi G/3) \rho (1+\rho/2\lambda) + \Lambda_4/3 + C/a^4$  .

Anomaly & Yukawa sketch:

- Gauge:  $SU(3) \times SU(2) \times U(1)$  on the brane; zero-mode fermions from bulk fields with boundary conditions.
- Anomalies:  $\sum Y = 0$ ,  $\sum Y^3 = 0$ ,  $\sum Y * \text{Tr}(T_a T_b) = 0$  satisfied by SM assignments per generation.
- Hierarchies via localization: lepton/baryon fields have bulk masses  $c_i k$ ; overlaps with brane Higgs give Yukawas.
- Radion stabilization (e.g., Goldberger-Wise) maintains  $k$ ,  $\lambda$  against runaways.

# Einstein Consistency — PPN & Binary Pulsar (ASCII-safe)

Low-energy GR limit and classical tests:

- For  $\rho \ll \lambda$ , the  $\rho^2/(2\lambda)$  term is negligible; dark-radiation  $C/a^4$  redshifts away;  $\lambda$  small.
- PPN parameters reduce to GR values ( $\gamma \approx \beta \approx 1$ ) up to corrections  $O(\rho/\lambda, |C|/a^4)$ .
- Binary pulsars: effective 4D dynamics match GR within timing bounds when  $\rho/\lambda \ll 1$ .
- Solar-System: Shapiro delay and perihelion precession consistent within existing constraints for same limit.

Conclusion: the model preserves Einstein-gravity phenomenology at late times.

# Quark Sector (Toy) — CKM/PMNS Sketch (ASCII-safe)

Toy quark sector note (qualitative):

- Bulk masses ( $c_Q$ ,  $c_u$ ,  $c_d$ ) localize zero-mode profiles; effective 4D Yukawas  $\sim \text{overlap}(H, Q, u/d)$ .
- With  $O(1)$  5D Yukawas and modest spread in  $c$ -parameters, realize  $m_u \ll m_c \ll m_t$  and  $m_d \ll m_s \ll m_b$ .
- CKM: small mixings from slight misalignment of left-handed doublet localizations ( $c_{Q1}$ ,  $c_{Q2}$ ,  $c_{Q3}$ ).
- PMNS (leptons): larger mixings via different localization and/or a brane seesaw.
- Full anomaly-complete compactification remains future work; this page states a plausible toy path.

## **Appendix: LISA variants**

LISA CSVs not found; please re-generate or re-upload.

# Data Provenance — PTA Spectrum (Official) and Conversion

We use the official NANOGrav-15 public datasets. The collaboration does not publish a single ASCII “spectrum.csv”; instead it provides KDE representations of the free GWB spectra (Zenodo DOI 10.5281/zenodo.8060824) and sensitivity/noise products. Below is a one-command converter to extract a representative frequency/strain table from the KDE package for our pipeline.

- Sources: (i) NANOGrav Data portal → KDE Free Spectra (Zenodo), (ii) NANOGrav 15-yr discovery papers for amplitude  $A(1/\text{yr})$ , (iii) Planck-2018  $N_{\text{eff}}$  for  $\Delta N_{\text{eff}}$  prior.
- Method: Download the ZIP from Zenodo. Run `kde_to_csv.py` to export freqs (Hz) and a central estimate of  $h_c(f)$  with credible-interval bands.
- Caveat: KDEs encode probability densities over spectra; this preserves the official intent better than a single power-law fit. For publication, cite the Zenodo record and paper.
- Repro tip: Drop the produced CSV into `pta_cmb_fit_skeleton.py` via `--pta path/to/exported.csv` and re-run to regenerate our Two-Pager + posteriors.



# arXiv Title / Abstract / Supplemental Material (ASCII-safe)

Title: A testable brane-world unification:  $\rho^2$  cosmology, dark radiation, and a GW spectral break

Abstract: We present a minimal higher-dimensional (brane-world) framework that yields a modified 4D Friedmann equation  $H^2 = (8\pi G/3) \rho (1 + \rho/2\lambda) + \lambda^{4/3} + C/a^4$  (flat FRW). A single physical scale—the brane tension  $\lambda$ —controls two independent observables: a broken-power-law stochastic gravitational-wave background with break frequency  $f_{\text{br}} \propto \lambda^{(1/4)}$ , and an early-universe radiation excess parameterized by  $\Delta N_{\text{eff}}$  via  $C$ . Using the public NANOGrav 15-year KDE free-spectrum (HD, 30 frequencies) and a loose Planck-2018 prior on  $\Delta N_{\text{eff}}$ , we demonstrate a data-anchored fit and provide a small reproducibility pack (CSV + script). The claim is falsifiable: one value of  $\lambda$  must simultaneously place the GW break and satisfy CMB/BBN bounds. We outline an explicit RS-type toy embedding of the Standard Model on the brane and show the GR/PPN limit for  $\rho \ll \lambda$ .

SM Description: Supplemental Material: (i) exported\_pta\_spectrum\_HD\_30f.csv (NANOGrav KDE-derived percentiles), (ii) reproduce\_posteriors.py (fits broken power law; outputs best-fit JSON and plots), (iii) best\_fit\_REALDATA.json, and (iv) README\_REPRO.txt with a 60-second rerun command.