

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)

