

F-theory SU(5) Snapshot → Standard Model on the Brane

Goal: show one credible path from a higher-D string setup to the exact Standard Model ($SU(3) \times SU(2) \times U(1)$), with 3 chiral families and realistic Yukawa textures, while exporting parameters to cosmology (k , M_5 , λ).

Geometry & Gauge

- Elliptically fibered Calabi–Yau fourfold; $SU(5)$ gauge symmetry on a 7-brane stack. Hypercharge flux breaks $SU(5) \rightarrow SM$. The hypercharge remains massless with appropriate flux conditions.

Matter & Families

- 10 and 5_H matter curves host quarks/leptons. Three-family chirality from integral flux quanta (index theorems). Right-handed neutrinos via gauge singlet curves or bulk modes.

Yukawa Couplings

- Yukawas localize at codimension-3 enhancement loci ($E_6/SO(12)$). Texture hierarchies from wavefunction overlaps; CKM/PMNS angles via small geometric deformations.

Anomalies & Consistency

- Green–Schwarz anomaly cancelation; RR tadpoles balanced by flux and brane wrappings. Check moduli stabilization (KKLT/LVS) and supersymmetry conditions in the compact bulk.

Parameter Map → Cosmology

- Warped throat parameter k and 5D Planck mass M_5 determine effective 4D coupling G and the brane tension λ . After stabilization, export $\{k, M_5, \lambda\} \rightarrow \{G, \Lambda_4, \rho^2, \blacksquare\}$ in FRW.
- Observable handles: GW spectral break $f_{\text{br}}(\lambda)$ and dark radiation $C \leftrightarrow \Delta N_{\text{eff}}$. BBN enforces $T_x > \text{few MeV} \rightarrow$ lower bound on λ . Lab gravity bounds constrain (k, M_5) .

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

Deliverable: combine this snapshot with the joint-fit notebook to constrain λ and C , then iterate back to compactification choices if needed.