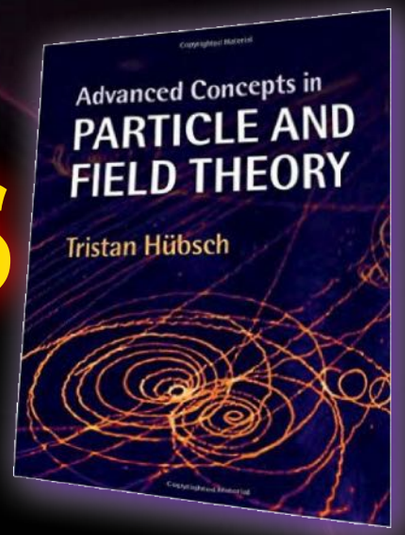
Quantum Strings & Cosmology



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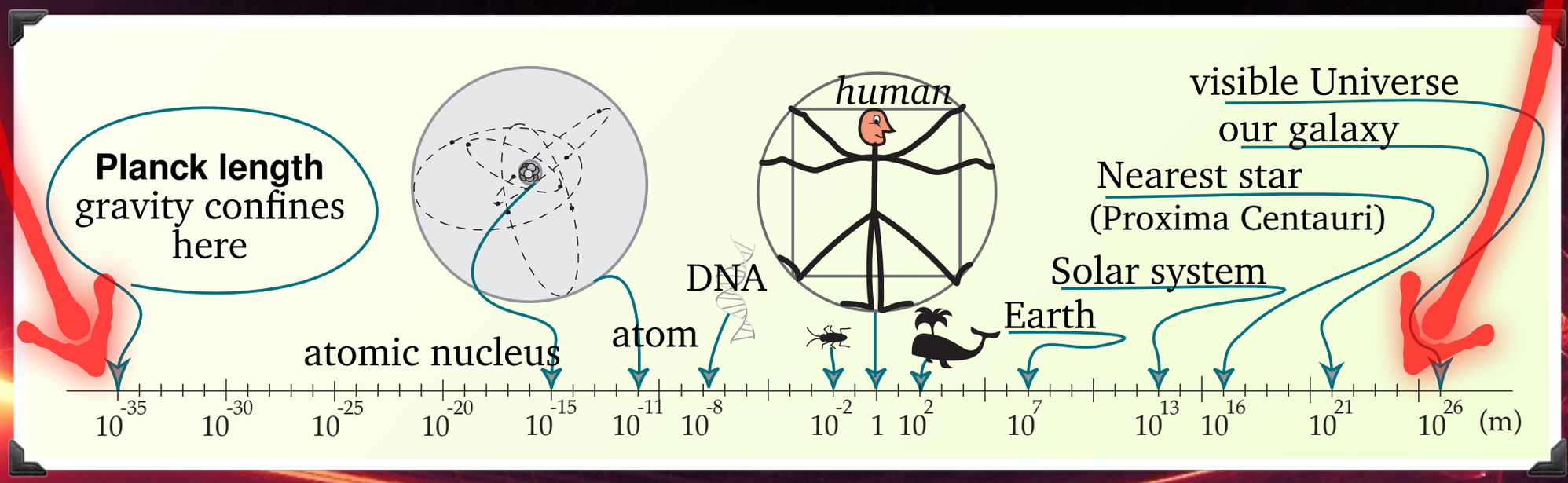

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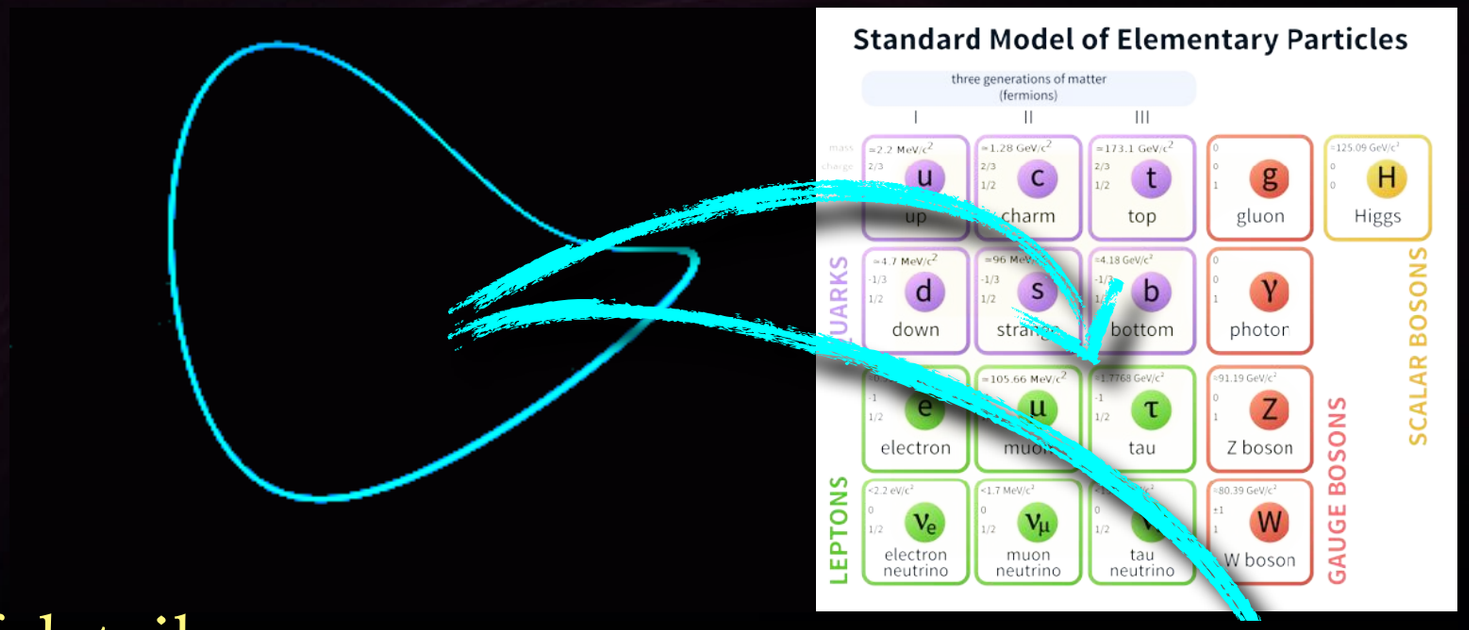
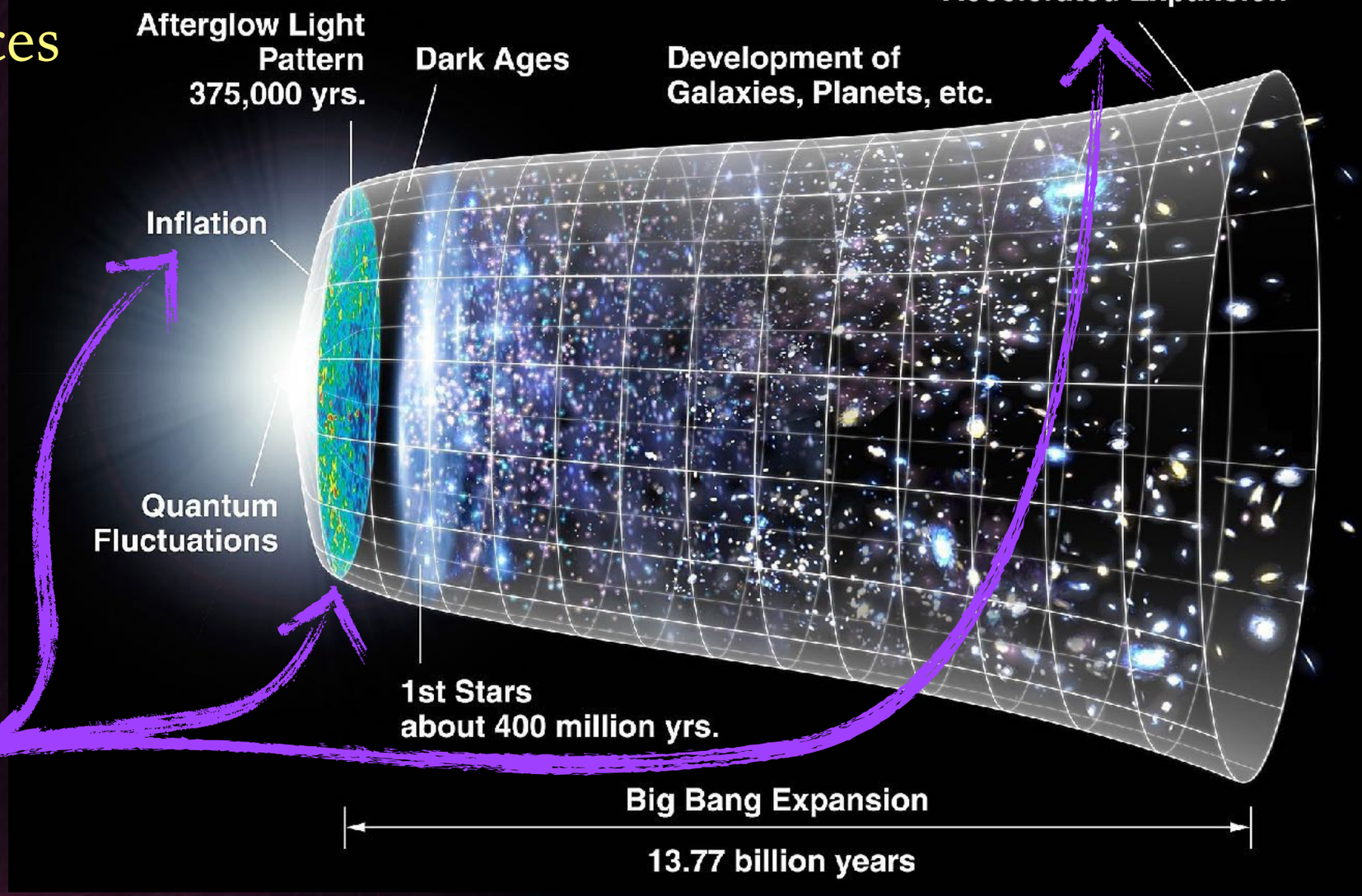


- 74: Standard Model w/lots of details
  - Fundamental forces
  - Fermion masses
  - ’80: *ν-mixing*
- 22 Years Ago… (Λ-CDM)
- Shadows of the Invisible (dark energy & dark matter too)



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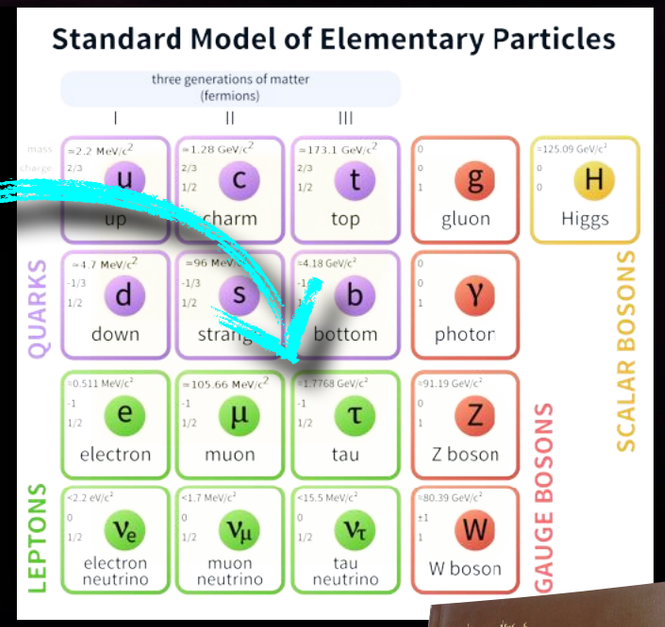
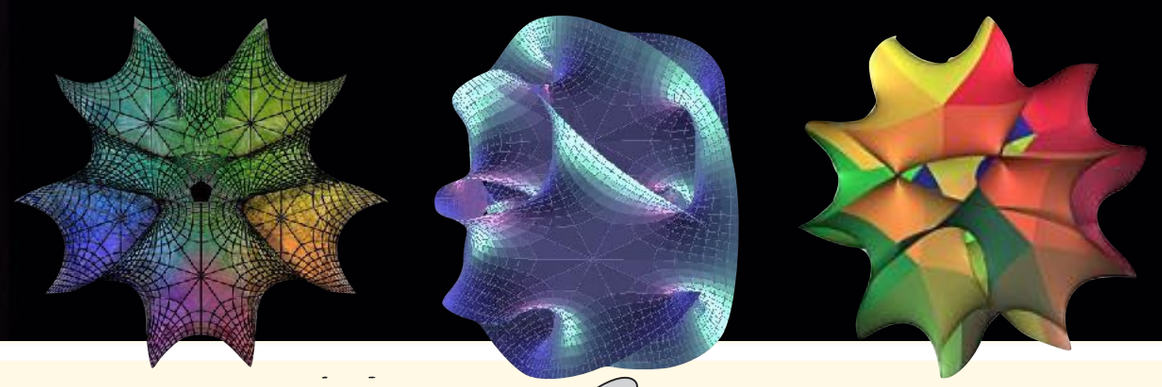
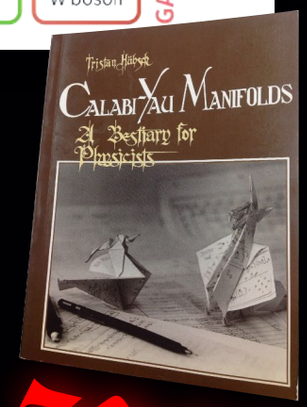
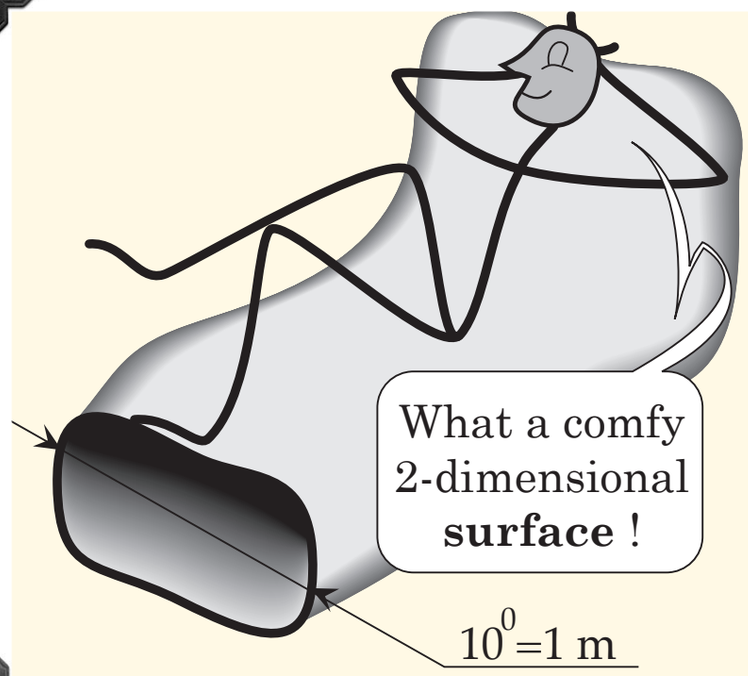


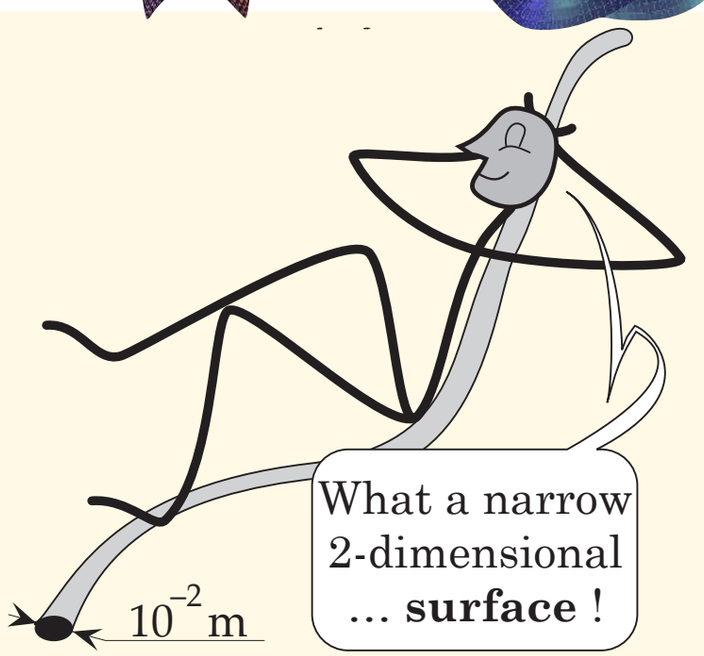
- Superstrings propagate consistently
  - in (9+1)D spacetime, e.g., with $E_8 \times E_8$ gauge group
  - Can be ***compactified***

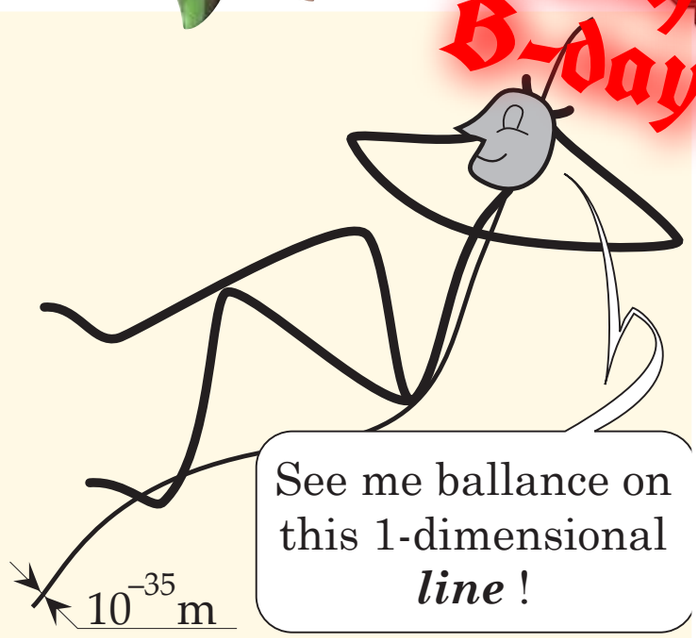




30th! B-day







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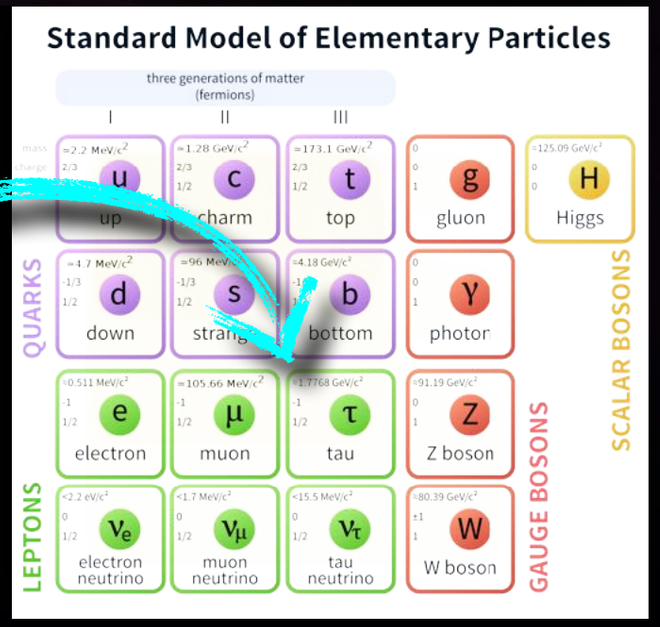

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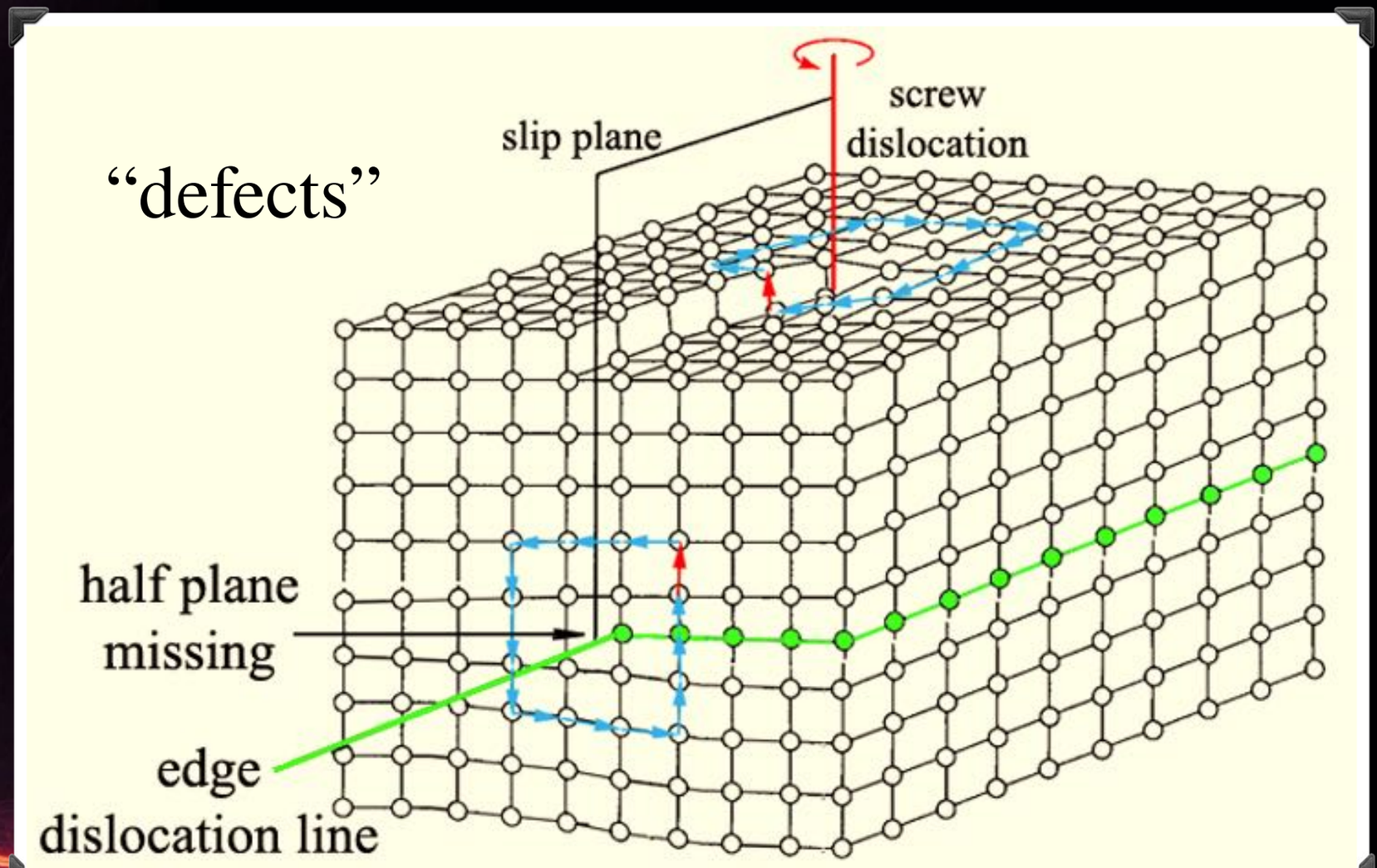

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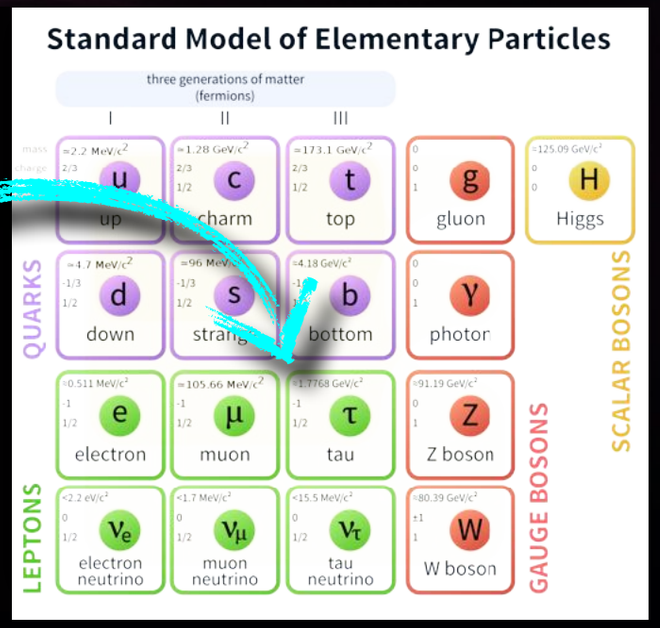

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  } : *"hide" the extra* dimensions

- $E_8 \times E_8 \to SU_c(3) \times SU_{w,L}(2) \times U_y(1)$
  - …3 generations of chiral fermions, Higgs, etc.
  - fermion masses spanning $\sim (10^0 \cdots 10^{-11}) \langle H \rangle$
  - $\begin{bmatrix} 0 & m \\ m & M \end{bmatrix} \to \approx \left\{ \frac{m^2}{M}, M \right\}$; $\begin{cases} m^2/M \sim 1.1\,\text{eV} \\ \Rightarrow M \geqslant 10^{+11} \langle H \rangle \end{cases}$ *seesaw*

  } $\sim$? 🤞

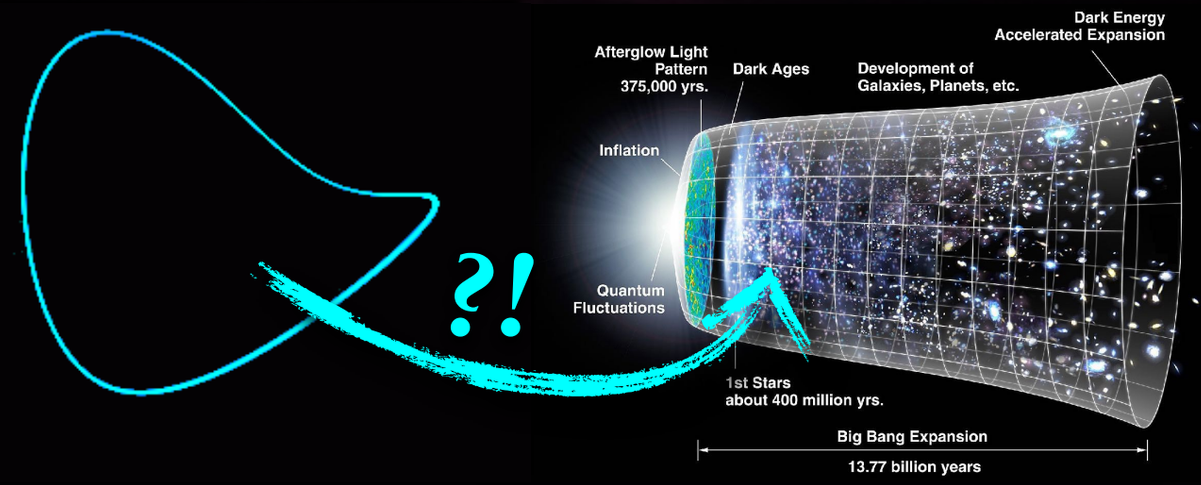
- Supersymmetry must be "broken"

🤔 *somehow…*

Topping the Already Tall Order

Λ-CDM

Cold Dark Matter



- Candidates in GUT and Superstring models → WiP 🤞

- 1917, A. Einstein; + 81 years: $\rightarrow \Lambda \approx 1.1\times10^{-52}\,\mathrm{m}^{-2} > 0$

- Einstein: $R_{\mu\nu} = \dfrac{8\pi G_N}{c^4}\left[T_{\mu\nu}(\tau) - \dfrac{1}{D-2} g_{\mu\nu}\left(g^{\rho\sigma}T_{\rho\sigma}(\tau)\right)\right]$ ← $g_{\mu\nu}(x; z, \theta)$

- Peculiar, "creased" + "compactified" models

  - Toy-model: axion+dilaton: $\boldsymbol{\tau} = \mathbf{a} + i g_s^{-1} e^{-\boldsymbol{\Phi}}$

big $\mathscr{W}^{3,1} \rtimes Y_\perp^2 \times Y^4$ small

- $g^{\mu\nu}\left((\nabla_\mu \nabla_\nu \tau) + \Gamma^\tau_{\tau\tau}(\nabla_\mu \tau)(\nabla_\nu \tau)\right) = 0$ *separation of variables* ← $\tau(x; z, \theta)$

- $\mathrm{d}s^2 = h_\parallel(z)^2\, g_{ij}^{(\mathrm{dS};\Lambda)}(x)\,\mathrm{d}x^i \mathrm{d}x^j \;+\; \Lambda^{-1} h_\perp(z)^2(\mathrm{d}z^2 + \mathrm{d}\theta^2) \;+\; (\mathrm{d}^2 y)_{Y^4}$

- Exponential mass-hierarchy: $M_P = M_*^2 \cdot \ell \cdot e^{+z_0/2} \cdot f(z_0)$ *breaks supersymmetry*

- Cosmological constant: $\Lambda = \Delta\omega^2 / 8\ell^2 > 0$ ⇝ $M_\Lambda = (M_{\mathrm{susy}}^2 / M_P)$ — *seesaw!*

so $M_{\mathrm{susy}} \sim$ 1–10 *TeV*

Thank You!

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