

Title: Particle Physics Lecture

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Collection: Particle Physics

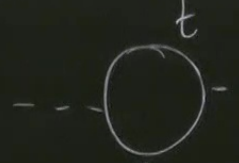
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URL: <https://pirsa.org/24030017>

Technically natural

Flavor problem

Fine-tuned



$$\alpha \sim y_t^2 \frac{\Lambda^2}{16\pi^2}$$

$$\sigma_{\text{QCD}} \sim \frac{g_s^2}{32\pi^2}$$

$$G_{\tau_s} \tilde{G}_{\tau_s}$$

Treating σ as a fine-tuning problem \Rightarrow axion

Cosmological Constant

The electron mass

$$\underline{m\psi\psi}$$

$$\psi \rightarrow e^{i\alpha}\psi$$

$$\delta m \sim m \alpha \log E$$

$$\delta E \propto \frac{\alpha}{r} \Rightarrow \alpha \Lambda$$



The higgs mass

The higgs mass

$h(1, 2, \frac{1}{2})$

The photon mass

gauge invariance

$$-\frac{1}{4} F_{\mu\nu}^2 - m^2 A_\mu^2$$
$$m^2 (A_\mu - \partial_\mu \phi)$$
$$A_\mu \rightarrow A_\mu + \partial_\mu \alpha(x)$$
$$\phi \rightarrow \phi + \alpha(x)$$

The electron mass

$$\underline{m\psi\psi}$$

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The higgs mass

The photon mass

gauge invariance

The Hierarchy problem - Naturalness

$$m_t = 173 \text{ GeV}$$

$$m_c$$

$$m_n = 2 \text{ MeV}$$

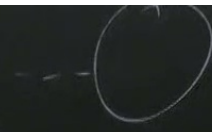
$$10^{17} \begin{array}{c} \uparrow \\ M_{\text{Pl}} = 10^{19} \text{ GeV} \\ \downarrow \\ m_h = 125 \text{ GeV} \\ \uparrow \\ \Lambda = 10^{-122} M_{\text{Pl}}^4 \\ \downarrow \\ \Lambda_{\text{min}} \sim 10^{-60} M_{\text{Pl}}^4 \end{array}$$

mass

$$h(x, y, z, t)$$

$$m^2 |h|^2$$

$$\mathcal{L}(\partial_\mu h)$$



what physics

do I add to cancel this

mass

$$h \rightarrow h + c$$

invariance

$$A_\mu^2$$

$$(\Lambda_\mu - \partial_\mu \phi)$$

$$A_\mu \rightarrow A_\mu + \partial_\mu \alpha(x)$$

$$\phi \rightarrow \phi + \alpha(x)$$

$$\rho = \int d^3k \frac{1}{2} \sqrt{k^2 + m^2} \alpha \Lambda_{uv}$$

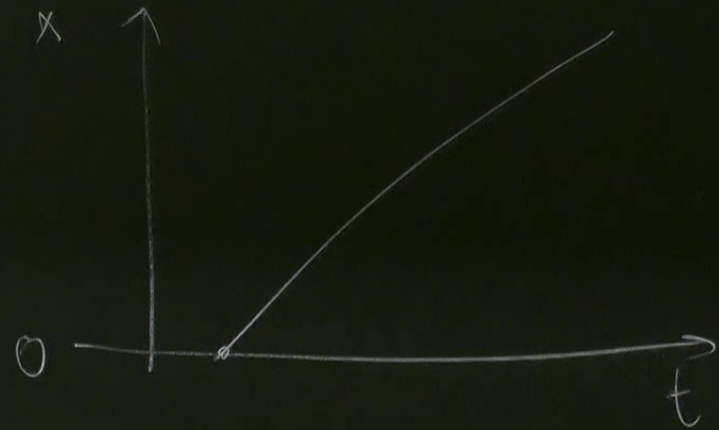
Weinberg 1988

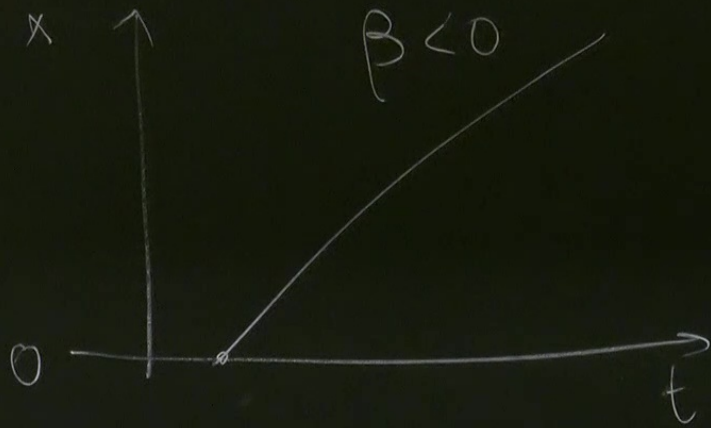
$$H_{\text{vac}} \sim \frac{\Lambda_{cc}^2}{M_{pl}}$$

$$H_{\text{vac}} = 10^{-33} \text{ eV}$$

$$\Lambda_{SM} \gg \Lambda_{cc} - V(\phi)$$

$$x(t) = x(\mu_0) - 2\beta t$$
$$x = \frac{\Delta G \pi^2}{g^2} \quad t = -\log \frac{E}{\mu_0}$$





$$\Lambda_{12} = \Lambda_{uv} e^{\frac{8n^2}{\beta g^2 (uv)}}$$

$$\Lambda_{IR} = \Lambda_{UV} e^{\frac{8\pi^2}{\beta g^2(uv)}}$$

Dimensional transmutation

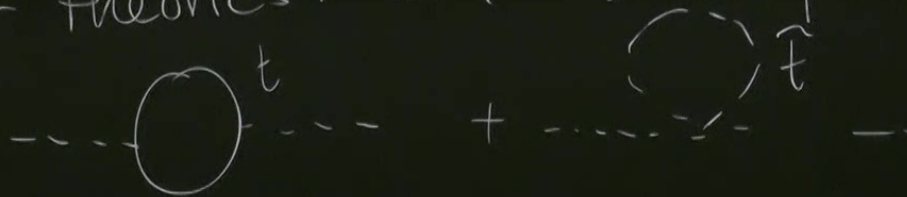
Technicolor theories: SM is composite @ TeV

$$\Lambda_{IR} = \Lambda_{UV} e^{-\frac{8\pi^2}{\beta g^2(uv)}}$$

Dimensional transmutation

① Technicolor theories: SM is composite @ TeV

② SUSY

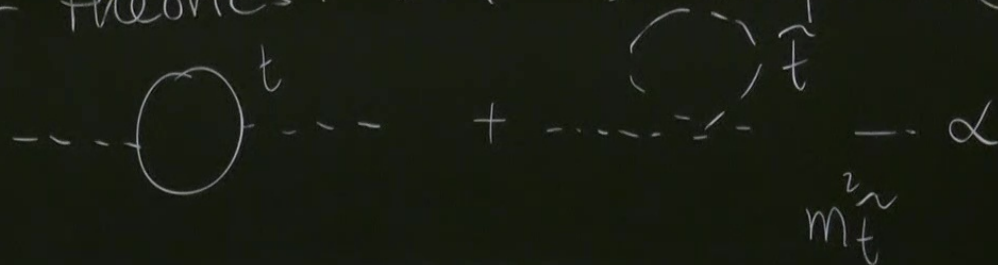


$$\Lambda_{IR} = \Lambda_{UV} e^{\frac{8\pi^2}{\beta g^2(uv)}}$$

Dimensional transmutation

① Technicolor theories: SM is composite @ TeV

② SUSY

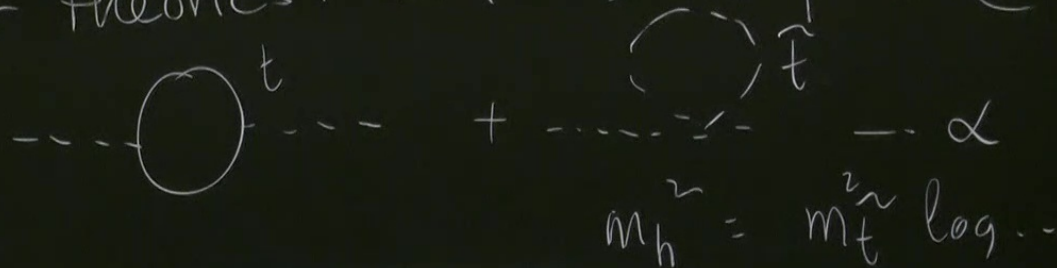


$$\Lambda_{IR} = \Lambda_{UV} e^{\frac{8\pi^2}{\beta g^2(uv)}}$$

Dimensional transmutation

① Technicolor theories: SM is composite @ TeV

② SUSY



The diagram shows two Feynman diagrams representing loop corrections to the top quark mass. The first diagram is a solid circle with a top quark line entering from the left and exiting to the right, labeled with a superscript 't'. The second diagram is a dashed circle with a top squark line entering from the left and exiting to the right, labeled with a superscript 't' and a tilde symbol. The two diagrams are separated by a plus sign. To the right of the diagrams, there is a proportionality symbol \propto and the equation $m_h^2 = m_t^2 \log \dots$.