Title: Particle Physics Lecture

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Collection: Particle Physics

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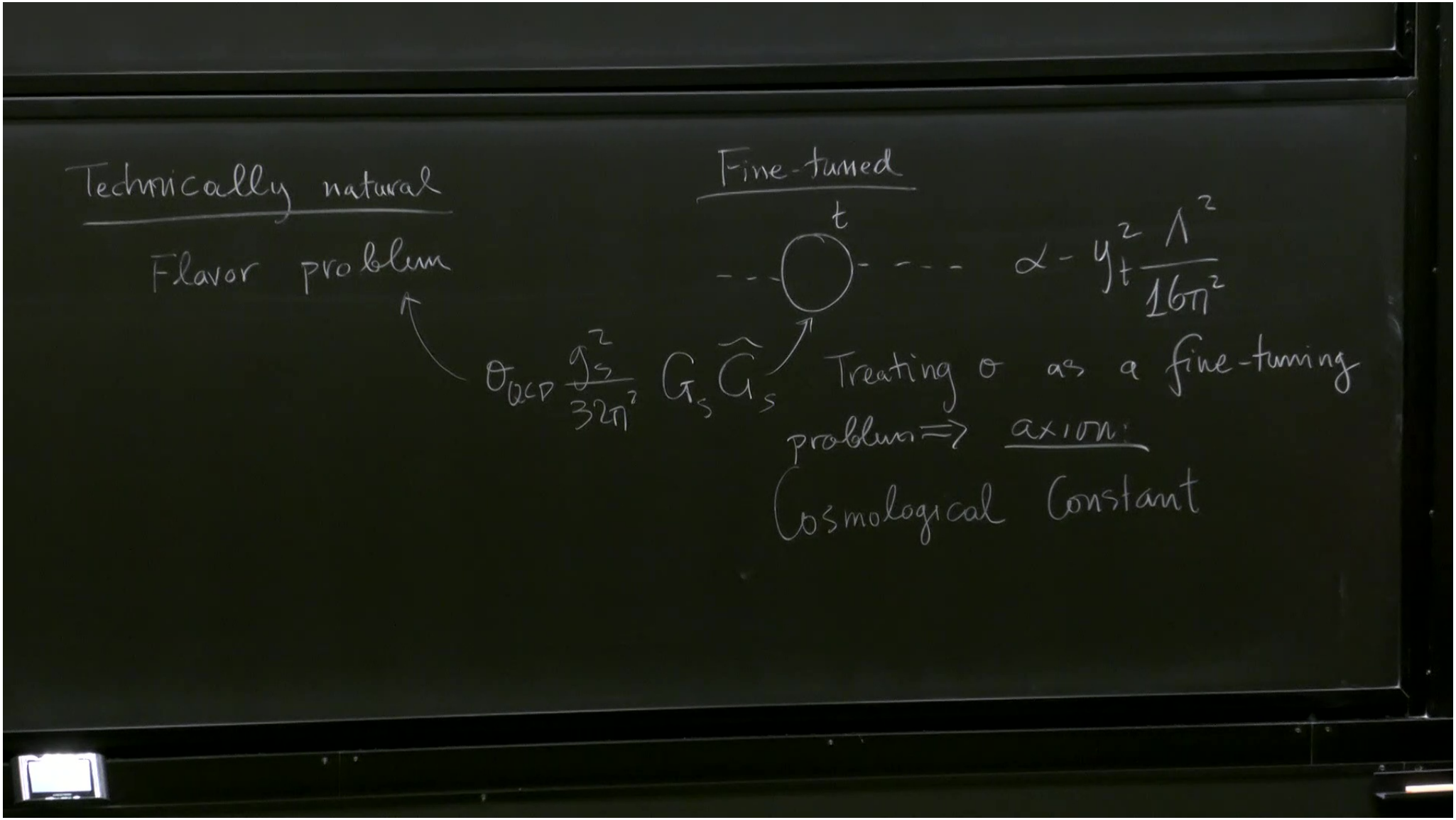

Technically natural
Flavor problem
Fine-tuned
t
$\alpha - y_t^2 \frac{\Lambda^2}{16\pi^2}$
$\theta_{QCD} \frac{g_s^2}{32\pi^2} G_s \tilde{G}_s$
Treating θ as a fine-tuning problem ⇒ axion:
Cosmological Constant

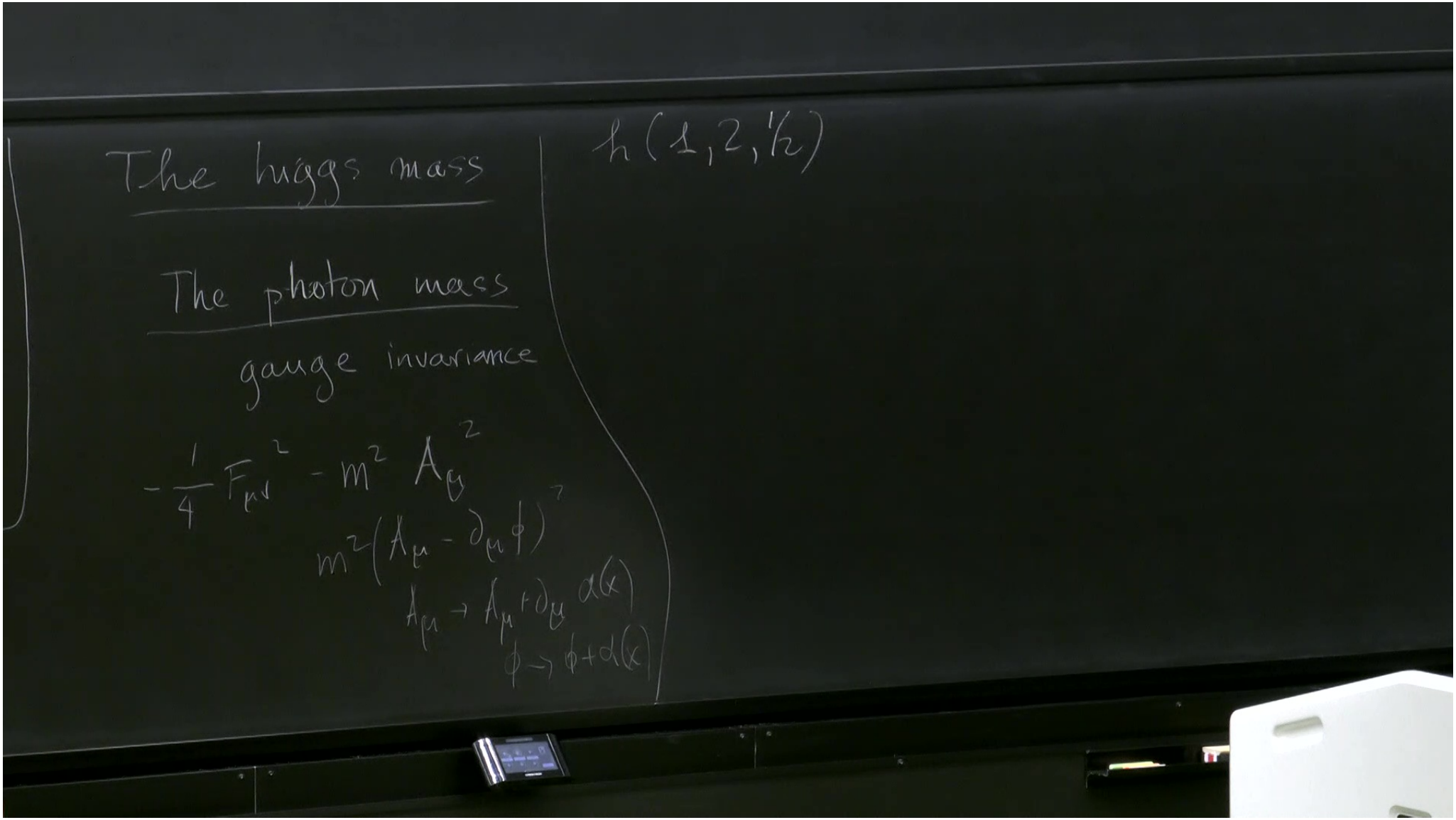
The electron mass

$m\psi\psi$ $\quad \psi \to e^{i\alpha}\psi$

$\delta m \sim m \frac{\alpha}{EM} \log E$

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

The huggs mass

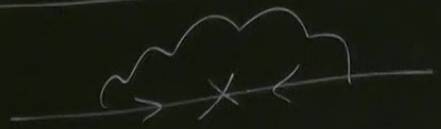

The higgs mass
The photon mass
gauge invariance
$-\frac{1}{4}F_{\mu\nu}^2 - m^2 A_\mu^2$
$m^2(A_\mu - \partial_\mu \phi)^2$
$A_\mu \to A_\mu + \partial_\mu \alpha(x)$
$\phi \to \phi + \alpha(x)$
$h(1,2,1/2)$

The electron mass

$m\psi\psi$ $\quad \psi \to e^{i\alpha}\psi$

$\delta m \sim m \alpha \log \frac{E}{m}$

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



The higgs mass

The photon mass

gauge invariance

The hierarchy problem – Naturalness

$m_t = 173$ GeV

m_c

$m_u = 2$ MeV

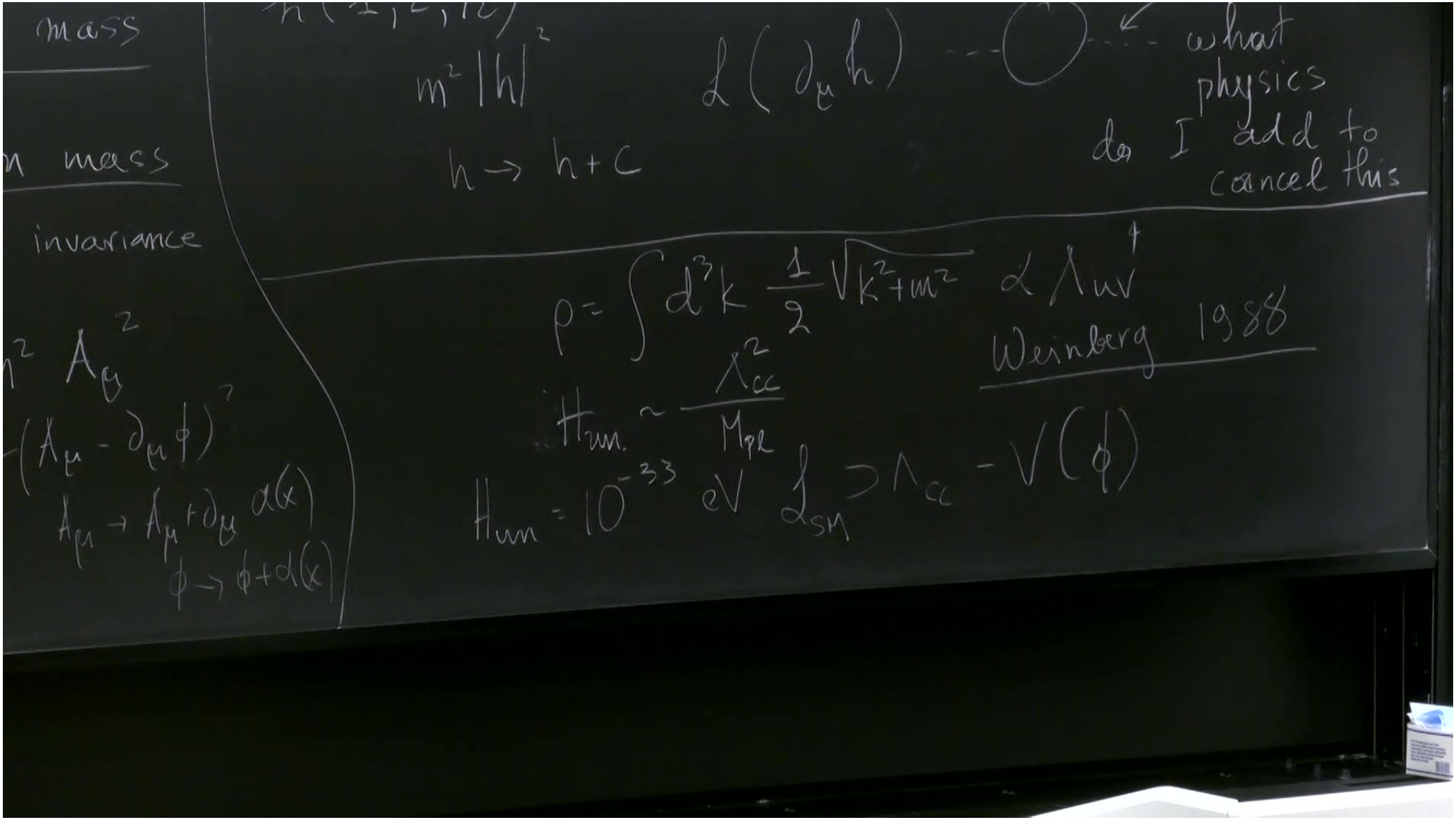
$M_{Pl} = 10^{19}$ GeV

10^{17}

$m_h = 125$ GeV

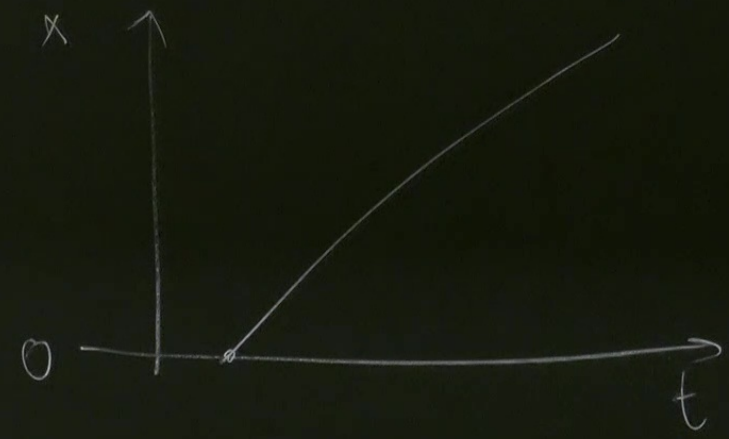
$\Lambda = 10^{-122} M_{Pl}^4$

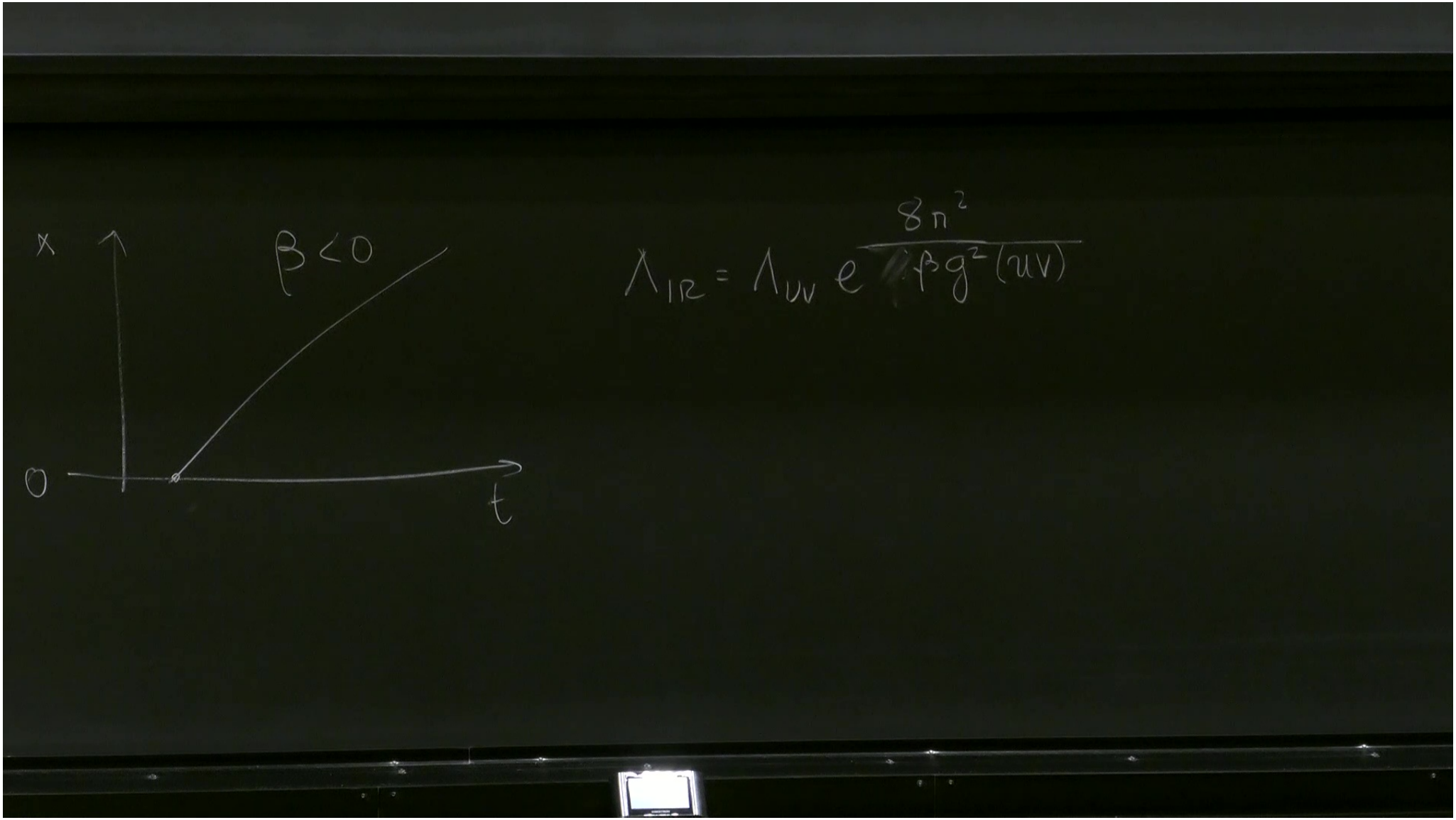
$\Lambda_{min} \sim 10^{-60} M_{Pl}^4$


mass
$m^2|h|^2$
$\mathcal{L}(\partial_\mu h)$
what physics do I add to cancel this
$h \to h + c$
n mass
invariance
$\rho = \int d^3k \frac{1}{2}\sqrt{k^2+m^2} \propto \Lambda_{UV}^4$
Weinberg 1988
$H_{inf.} \sim \frac{\Lambda_{CC}^2}{M_{PL}}$
$H_{inf} = 10^{-33}$ eV
$\mathcal{L}_{SM} \supset \Lambda_{CC} - V(\phi)$
$A_\mu \to A_\mu + \partial_\mu \alpha(x)$
$\phi \to \phi + \alpha(x)$

$$x(t) = x(\mu_0) - 2\beta t$$

$$x = \frac{16\pi^2}{g^2} \qquad t = -\log \frac{E}{\mu_0}$$




x
β<0
0
t
$\Lambda_{IR} = \Lambda_{UV} e^{\frac{8\pi^2}{\beta g^2(\mu V)}}$

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

Dimensional transmutation

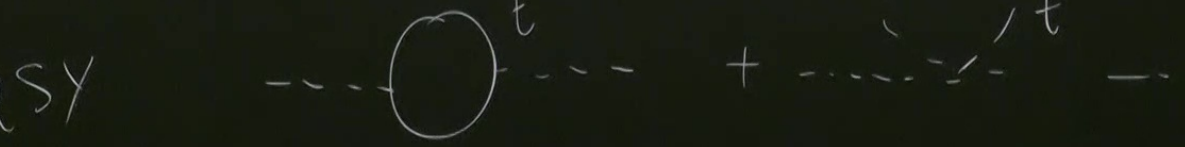
Technicolor theories: SM is composite @ TeV

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

Dimensional transmutation

① Technicolor theories: SM is composite @ TeV

② SUSY



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Dimensional transmutation

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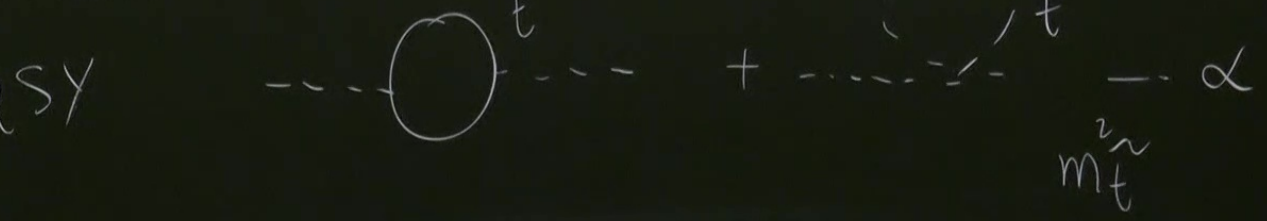

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Dimensional transmutation

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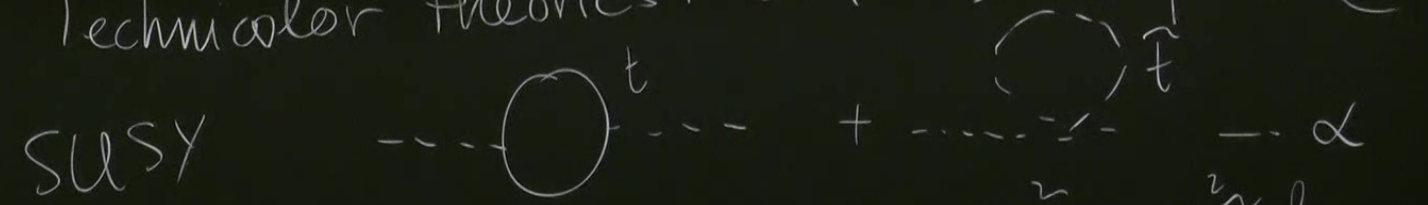

$$m_h^2 = m_{\tilde{t}}^2 \log\ldots$$