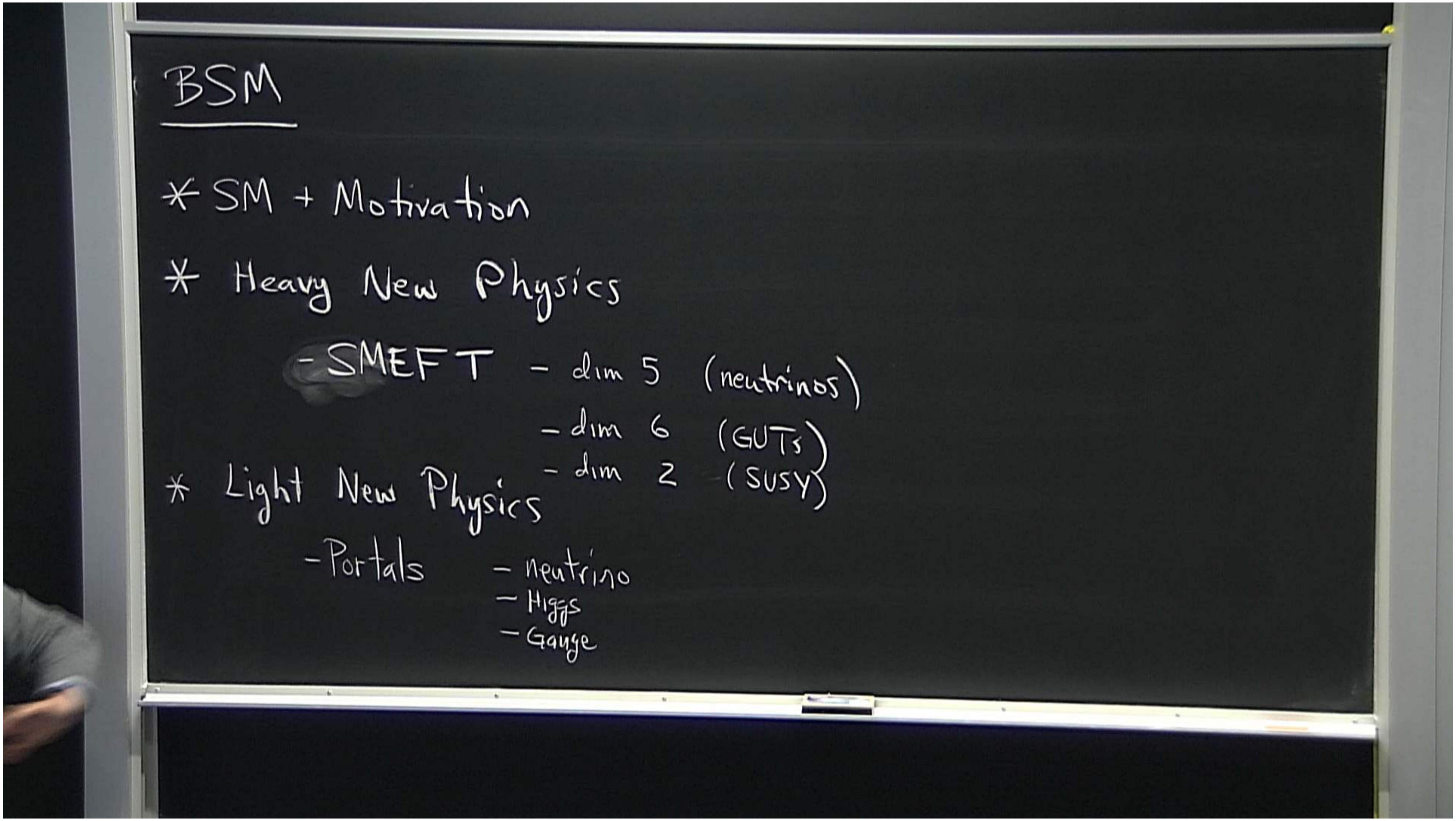
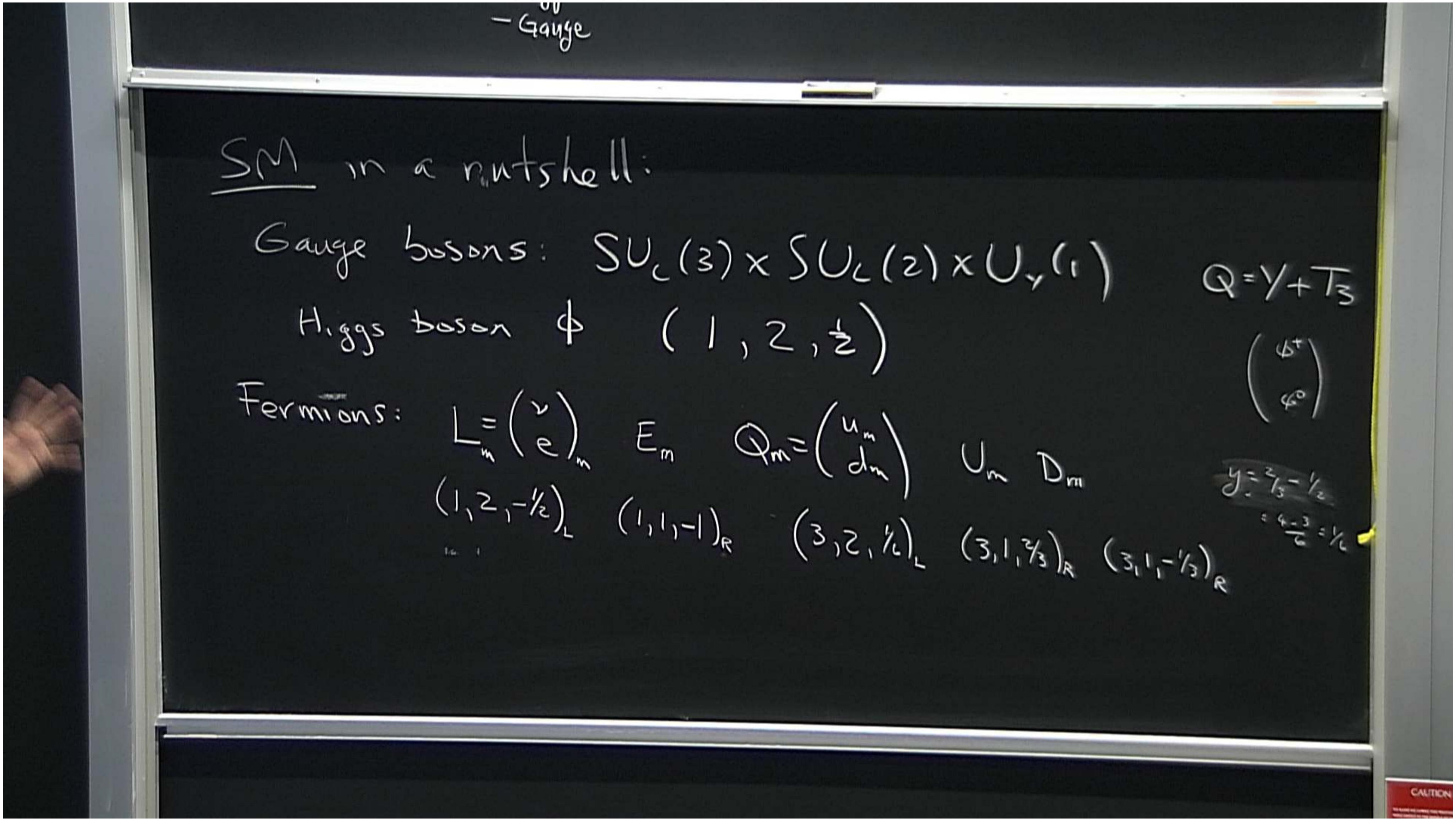
Title: PSI 17/18 - Beyond Standard Model - lecture 1

Date: Feb 16, 2018 03:00 PM

URL: http://pirsa.org/18020106

Abstract:


BSM
* SM + Motivation
* Heavy New Physics
- SMEFT - dim 5 (neutrinos)
- dim 6 (GUTs)
- dim 2 (SUSY)
* Light New Physics
- Portals - neutrino
- Higgs
- Gauge


- Gauge
SM in a nutshell:
Gauge bosons: $SU_c(3) \times SU_L(2) \times U_Y(1)$
$Q = Y + T_3$
Higgs boson ϕ $(1, 2, \frac{1}{2})$
$\begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix}$
Fermions: $L_m = \begin{pmatrix} \nu \\ e \end{pmatrix}_m$ E_m $Q_m = \begin{pmatrix} u_m \\ d_m \end{pmatrix}$ U_m D_m
$(1, 2, -\frac{1}{2})_L$ $(1, 1, -1)_R$ $(3, 2, \frac{1}{6})_L$ $(3, 1, \frac{2}{3})_R$ $(3, 1, -\frac{1}{3})_R$
$y = \frac{2}{3} - \frac{1}{2} = \frac{4-3}{6} = \frac{1}{6}$

- SMEFT
  - dim 5 (neutrinos)
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* Light New Physics

- Portals
  - neutrino
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$\hbar = c = k_B = 1$

$S = \int d^4x \, \mathcal{L}$

$L_m = \begin{pmatrix} \nu \\ e \end{pmatrix}_m \quad E_m \quad Q_m = \begin{pmatrix} u_m \\ d_m \end{pmatrix} \quad U_m \quad D_m$

$(1,2,-\tfrac{1}{2})_L \quad (1,1,-1)_R \quad (3,2,\tfrac{1}{6})_L \quad (3,1,\tfrac{2}{3})_R \quad (3,1,-\tfrac{1}{3})_R$

$y = \tfrac{2}{3} - \tfrac{1}{2} = \tfrac{4-3}{6} = \tfrac{1}{6}$

$$\mathcal{L} = \underset{2}{\mu^2 \phi^\dagger \phi} + \underset{4}{\lambda (\phi^\dagger \phi)^2} \quad \underset{4}{F_{\mu\nu} F^{\mu\nu}}, \quad \underset{4}{\bar{\Psi} \not{D} \Psi} \quad \underset{4}{y_{mn} \bar{\Psi}_m \Psi_n \phi} \quad \underset{4}{D_\mu \phi^\dagger D^\mu \phi}$$

$[\Psi] = 3/2 \quad [A_\mu] = [\phi] = 1$

Why this problems?

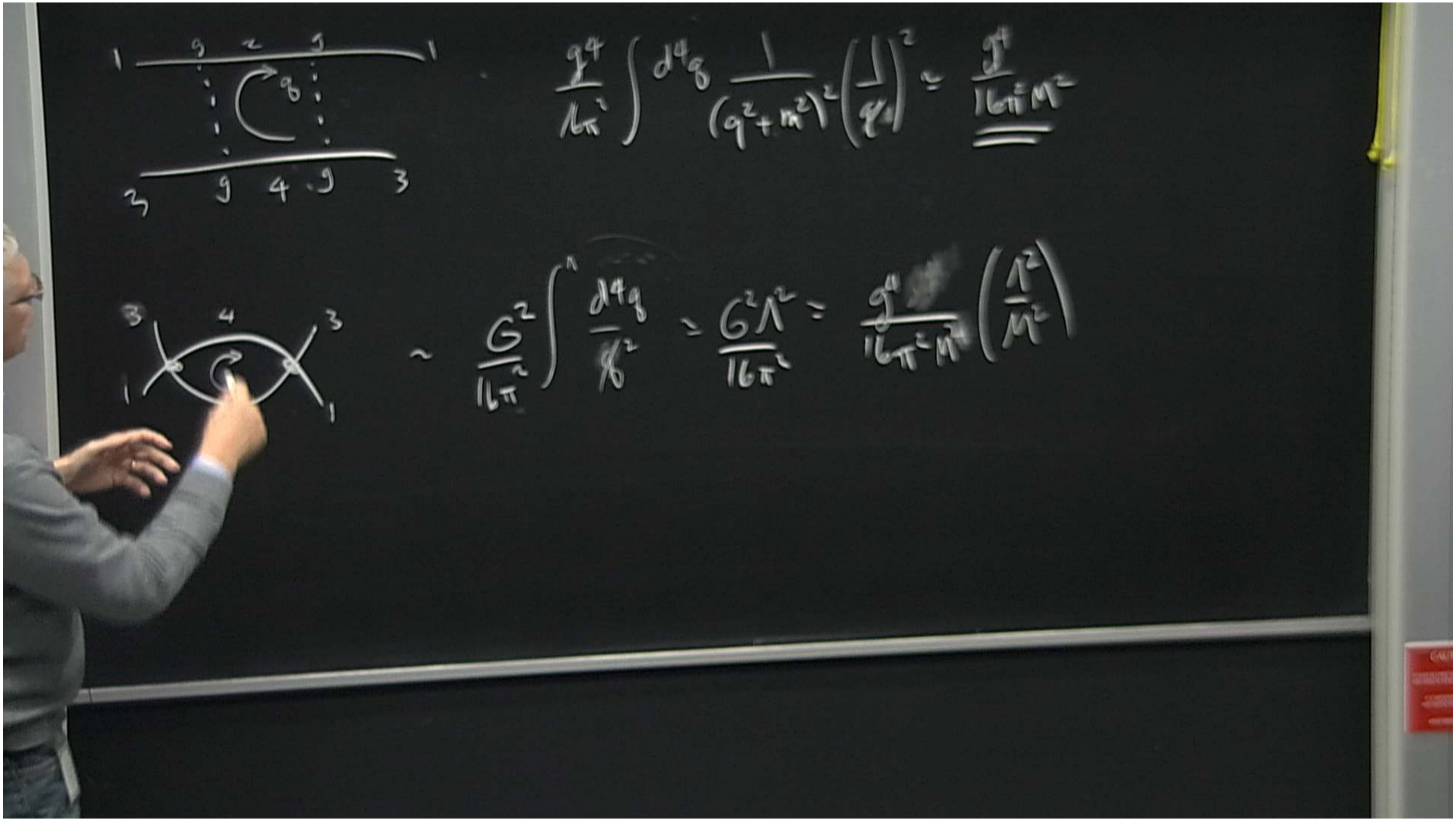
technically unnatural
- hierarchy problems

technically natural
- flavour problems (why 3 gen.)
- structure: why $SU_3 \times SU_2 \times U_1$?

BUT SM is a **huge** success in colliders up to 14 TeV

EFT Claim: any low-energy influence of very massive particle can be replaced in <u>all</u> observables by a collection of local* interactions involving only light fields. * to any finite order in $\frac{1}{M}$

$$\frac{1}{p^2+M^2} = \frac{1}{M^2} - \frac{p^2}{M^4} + \cdots \qquad G(x,y) = \frac{1}{-\Box+m^2} = \frac{1}{M^2}\delta^4(x-y) + \frac{\Box}{M^4}\delta^4(x-y) + \cdots$$


$\frac{g^4}{16\pi^2}\int d^4q \frac{1}{(q^2+m^2)^2}\left(\frac{1}{q^2}\right)^2 \simeq \frac{g^4}{16\pi^2 M^2}$
$\sim \frac{G^2}{16\pi^2}\int^{\Lambda} \frac{d^4q}{q^2} \simeq \frac{G^2\Lambda^2}{16\pi^2} = \frac{g^4}{16\pi^2 M^2}\left(\frac{\Lambda^2}{M^2}\right)$