

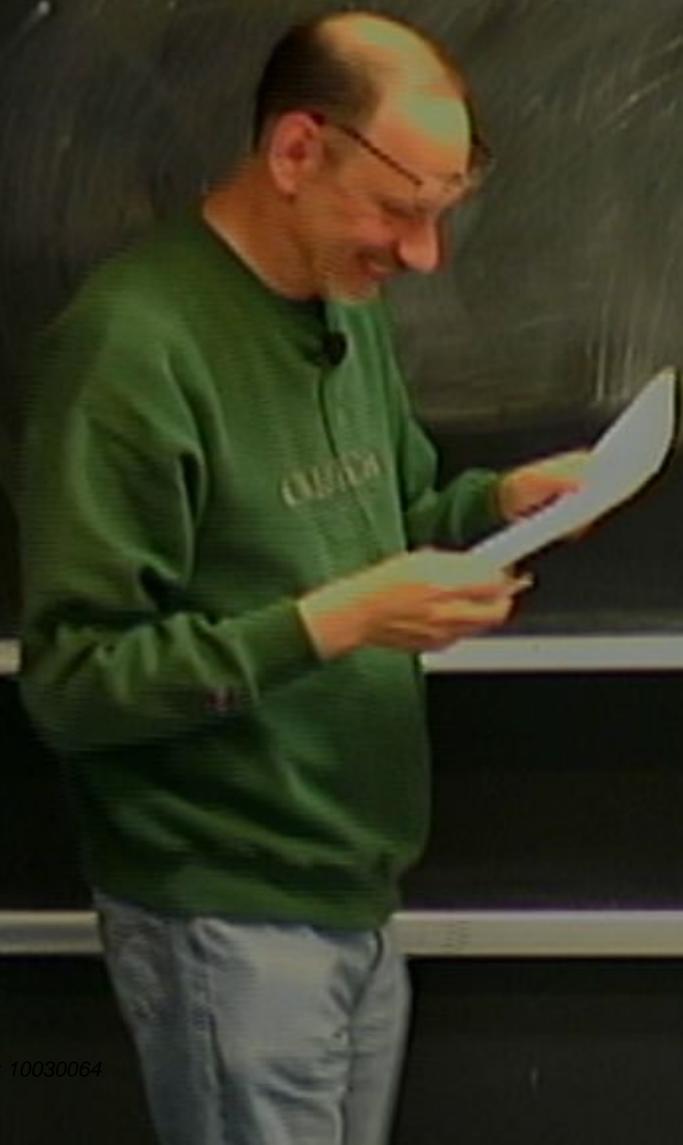
Title: Gauging Baryon and Lepton Number

Date: Mar 19, 2010 02:30 PM

URL: <http://pirsa.org/10030064>

Abstract: We investigate a simple theory where Baryon number (B) and Lepton number (L) are local gauge symmetries. In this theory B and L are on the same footing and the anomalies are cancelled by adding a single new fermionic generation. There is an interesting realization of the seesaw mechanism for neutrino masses. Furthermore there is a natural suppression of flavour violation in the quark and leptonic sectors since the gauge symmetries and particle content forbid tree level flavor changing neutral currents involving the quarks or charged leptons. Also one finds that the stability of a dark matter candidate is an automatic consequence of the gauge symmetry. Some constraints and signals at the Large Hadron Collider are briefly discussed.

Pavel Filaviez Perez, MTSW
arXiv: 1802.17544v2



Pavel Filaviez Perez, MTSW

arXiv: 1802.17544v2

[The rest of the chalkboard is heavily scribbled out with white chalk, obscuring any text that was originally written there.]

Pavel Filviez Pérez, MITSW

arXiv: 1002.1754v2

1) What do we love (about the standard model)

CALTECH

Pavel Filaviez Perez, MTSW

arXiv: 1802.1754v2

- 1) What do we love (about the standard model)
- 2) Gauge. By L Anomaly cancellation

Energy Density

quark sector
lepton sector

$$S(U(2))_c \times \underbrace{SU(2) \times U(1)}_{U(1) \times U(1)}$$

10-1h / 010-30-25

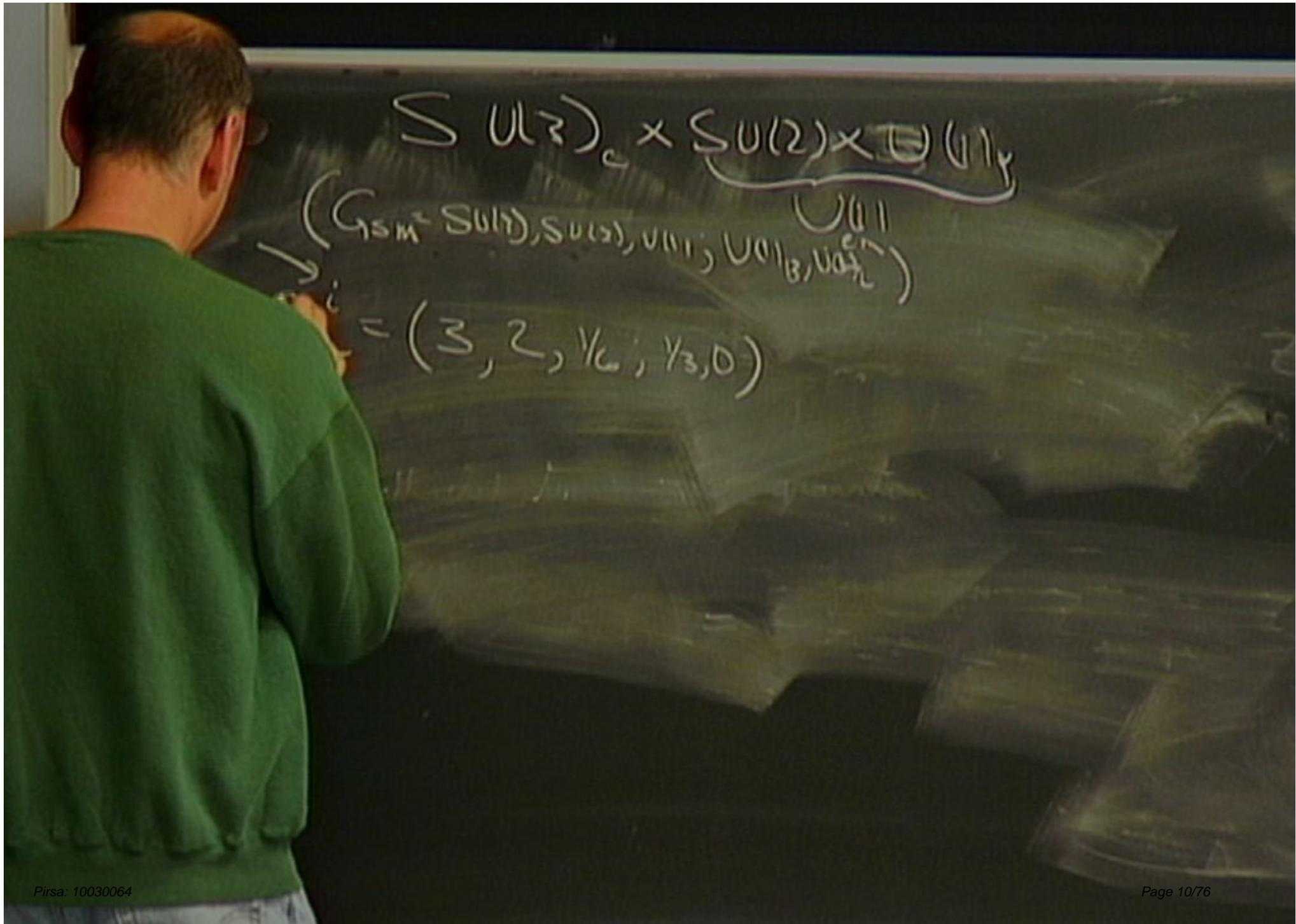
$$S(U(2))_c \times \underbrace{SU(2)}_{U(1)} \times U(1)$$

$$\left(\underbrace{G_{\text{SM}}}_{SU(3)} \times SU(2) \times U(1) \right) \times U(1)$$

10-1h / 07/03/03



$$\begin{aligned}
 & SU(2)_c \times \underbrace{SU(2) \times U(1)}_{U(1)} \\
 & \downarrow \left(G_{SM} = SU(3) \times SU(2) \times U(1) \right) \\
 & G_L^i = (3, 2, \frac{1}{6}, \frac{1}{3}, 0)
 \end{aligned}$$



$$S(U(2))_c \times SU(2) \times U(1)$$

$$(G_{SM} = SU(3), SU(2), U(1), U(1), U(1))$$

$$= (3, 2, 1/6, 1/3, 0)$$

$$S(U(2))_c \times \underbrace{SU(2) \times U(1)}_{U(1)}$$

$$\downarrow (G_{SM} = SU(3), SU(2), U(1), U(1)_B, U(1)_{EM})$$

$$Q_L^i = (3, 2, \frac{1}{6}, \frac{1}{3}, 0)$$

$$S(U(3))_c \times SU(2)$$

$$(G_{SM} = SU(3), SU(2), U(1), U(1))$$

$$Q_L^i = (3, 2, \frac{1}{6})$$

$$U_R^i = (3, 1, \frac{2}{3})$$

$$d_R^i = (3, 1, -\frac{1}{3})$$

$$(3, 1, -\frac{1}{2}, 0, 1)$$

$$\downarrow \cup \left((15m^2 S_{11}), S_{11}, U_{11}, U_{11}, U_{11} \right)$$

$$\left(\frac{2}{3}, \gamma_2, \gamma_3, 0 \right)$$

$$\left(1, \frac{2}{3}, \gamma_3, 0 \right)$$

$$\left(1, 1, -\gamma_3, \gamma_3, 0 \right)$$

$$\left. \begin{array}{l} \\ \\ \end{array} \right\} L_L^i = \left(1, 2, -\gamma_2, 0, 1 \right)$$

$$P_R^i = \left(1, 1, -1, 0, 1 \right)$$

$(\text{Gram} = S_{11}^2, S_{12}, S_{13}, S_{22}, S_{23}, S_{33}, \dots)$

$(1, 2, \gamma_2, \gamma_3, 0)$
 $(3, 1, \gamma_1, \gamma_5, 0)$
 $(3, 4, \gamma_3, \gamma_3, 0)$

$L_L^i = (1, 2, -\gamma_2, 0, 1)$
 $e_R^i = (4, 1, -1, 0, 1)$
 $\gamma_R^i = (1, 1, 0, 0, 1)$

$H = (1, 2, \gamma_2, 0, 0)$

$$\downarrow \left(\underbrace{C_{10M} = S_{1111}}_{\text{Sym}}, S_{1122}, \underbrace{U_{1111}}_{\text{U(1)}}, \underbrace{U_{1122}}_{\text{U(1)}} \right)$$

$$Q_L^i = (3, 2, \gamma_2, \gamma_3, 0)$$

$$U_R^i = (3, 1, 2/3, \gamma_5, 0)$$

$$D_R^i = (3, 1, -\gamma_3, \gamma_3, 0)$$

$$L_L^i = (1, 2, -\gamma_2, 0, 1)$$

$$e_R^i = (1, 1, -1, 0, 1)$$

$$\nu_R^i = (1, 1, 0, 0, 1)$$

$$H = (1, 2, \gamma_2, 0, 0)$$

$(2, -\frac{1}{2}, 0, 1)$
 $(1, -1, 0, 1)$
 $(1, 0, 0, 1)$
 (0)

$$\frac{\text{odd } e_R}{\Lambda^2}$$

$$\tau_{P/Br}(P \rightarrow \pi^0 e^+ \nu) > 1.6 \times 10^{13} \text{ yrs}$$

$$\frac{\text{odd } e_R}{\Lambda^2}$$

$$\tau_{P/B_r}(P \rightarrow \pi^0 e^+ e^-) > 1.6 \times 10^{13} \text{ yr} \checkmark$$

$$\Lambda < 10^{16} \text{ GeV}$$

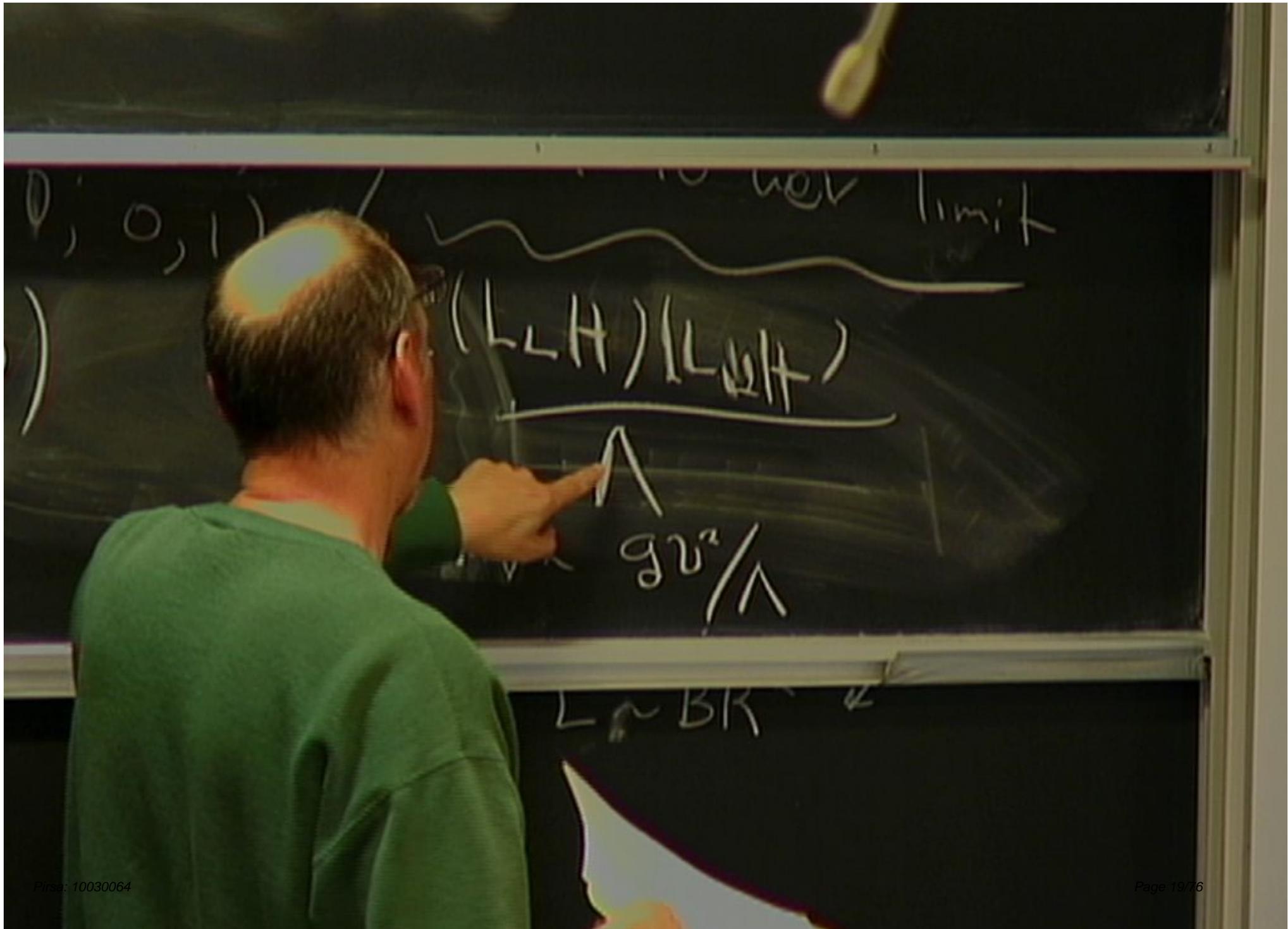
- $(\frac{1}{2}, 0, 1)$
- $(-1, 0, 1)$
- $(0, 0, 1)$

$(2, -\frac{1}{2}, 0, 1)$
 $(1, -1, 0, 1)$
 $(1, 0, 0, 1)$
 (0)

$$\frac{\text{odd } e_R}{\Lambda^2}$$

$$\tau_P / \text{Br}(P \rightarrow \pi^0 e^+ \nu) > 1.6 \times 10^{13} \text{ yr} \checkmark$$

$\Lambda \rightarrow 10^{16} \text{ GeV}$ limit



$$\frac{\text{odd } e_R}{\Lambda^2}$$

$$\tau_{P/\text{Br}}(P \rightarrow \pi^0 e^+) > 1.6 \times 10^{13} \text{ yr} \checkmark$$

$$\Lambda > 10^{16} \text{ GeV} \quad \text{limit}$$

$$\frac{g(\text{LH})/(\text{LWH})}{\Lambda}$$

$$m_\nu \sim \frac{g v^2}{\Lambda}$$

Favor changing neutral currents i

$b \rightarrow s$ $u \rightarrow u$



Pavel Filviez Perez, MITW

arXiv: 1002.1754v2

- 1) What do we love (about the standard model)
- 2) Gauge. By L Anomaly cancellation
- 3) Lagrange Density

Flavor changing neutral currents i



$b \rightarrow s$ $u\bar{u}$



$P = 2BR$
 $L = BR$

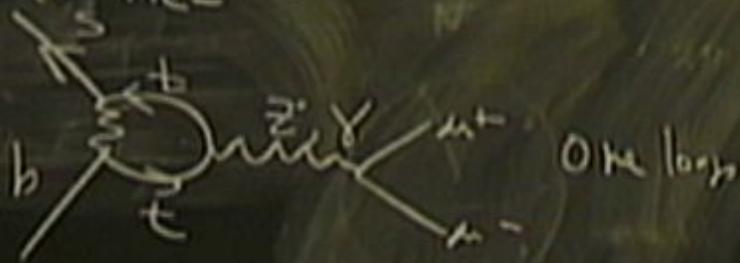
CALTECH

Perez, MNSW

love (about the standard model)

Anomaly cancellation

N.
 Flavor changing neutral currents
 at tree-



$b \rightarrow s$ $u\bar{u}$



Pavel Filviez Perez, MITW

arXiv: 1002.1754v2

- 1) What do we love (about the standard model)
- 2) Gauge. By L Anomaly cancellation
- 3) Lagrange Density

Anomaly Cancel (Barin)

$$A^{SM}(SU(3)^2 U(1)_B):$$

Anomaly Cancel (Barrin)

$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} (2 \cdot 3 \cdot \frac{1}{3})$$

\rightarrow
T_A T_B

\uparrow
Q_L

U_R

Anomaly Cancel (Bardeen)

$$A^{SM}(SU(3)^2 U(1)_B): \frac{1}{2} \left(\underset{\substack{\uparrow \\ T_1 T_2 T_3}}{2} \cdot 3 \cdot \frac{1}{3} \quad 3 \cdot \frac{1}{3} \right)$$



Anomaly Cancel (Barrin)

$$A^{SM}(SU(3)^2 U(1)_B) : \frac{1}{2} \left(\underset{\substack{\uparrow \\ T_1 T_2 T_3}}{2} \cdot 3 \cdot \frac{1}{3} \quad 3 \cdot \frac{1}{3} \right)$$

Anomaly Cancel (Barin)

$$A^{SM}(SU(3)^2 U(1)_B): \frac{1}{2} \left(\underset{\substack{\uparrow \\ T_1 T_2 T_3}}{2} \cdot \underset{\substack{\uparrow \\ Q_L}}{3} \cdot \frac{1}{3} - 3 \cdot \frac{1}{3} - 3 \cdot \frac{1}{3} \right) = 0$$

Anomaly Cancel (Barin)

$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} \left(\underset{\substack{\uparrow \\ T_1 T_2 T_3}}{2} \cdot \underset{\substack{\uparrow \\ Q_L}}{3} \cdot \frac{1}{3} - \underset{\substack{\uparrow \\ \psi}}{3} \cdot \frac{1}{3} - 3 \cdot \frac{1}{3} \right) = 0$$

$$A^{SM}(SU(3)^2 U(1)_B) =$$

Anomaly Cancel (Barin)

$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} (2 \cdot 3 \cdot \frac{1}{3} - 3 \cdot \frac{1}{3} - 3 \cdot \frac{1}{3}) = 0$$



$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} ($$

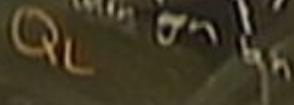
Q_L

Anomaly Cancel (Barin)

$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} (2 \cdot 3 \cdot \frac{1}{3} - 3 \cdot \frac{1}{3} - 3 \cdot \frac{1}{3}) = 0$$



$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} (3 \cdot 3 \cdot \frac{1}{3}) = \frac{3}{2}$$



Anomaly Cancel (Baryon)

$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} (2 \cdot 3 \cdot \frac{1}{3} - 3 \cdot \frac{1}{3} - 3 \cdot \frac{1}{3}) = 0$$



$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} (3 \cdot 3 \cdot \frac{1}{3}) = \boxed{\frac{3}{2}}$$



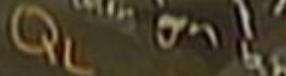
$$A^{SM}(U(1)_Y^2 U(1)_B) =$$

Anomaly Cancel (Barin)

$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} \left(2 \cdot 3 \cdot \frac{1}{3} - 3 \cdot \frac{1}{3} - \left(3 \cdot \frac{1}{3} \right) \right) = 0$$



$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} \left(3 \cdot 3 \cdot \frac{1}{3} \right) = \boxed{\frac{3}{2}}$$



$$A^{SM}(U(1)_Y U(1)_B^2) = \left[2 \cdot \frac{1}{6} \cdot 3 \cdot 3 \cdot \frac{1}{9} - \frac{1}{9} - \left(\frac{2}{3} \right) 3 \cdot 3 \cdot \frac{1}{9} \right]$$

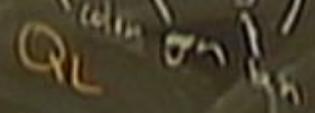


Anomaly Cancel (Barin)

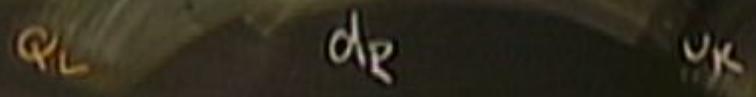
$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} (2 \cdot 3 \cdot \frac{1}{3} - 3 \cdot \frac{1}{3} - 3 \cdot \frac{1}{3}) = 0$$



$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} (3 \cdot 3 \cdot \frac{1}{3}) = \frac{3}{2}$$



$$A^{SM}(U(1)_Y U(1)_B^2) = [2 \cdot \frac{1}{6} \cdot 3 \cdot 3 \cdot \frac{1}{9} - (\frac{1}{3}) \cdot 3 \cdot 3 \cdot \frac{1}{9} - (\frac{2}{3}) \cdot 3 \cdot 3 \cdot \frac{1}{9}]$$



Anomaly Cancel (Baryon)

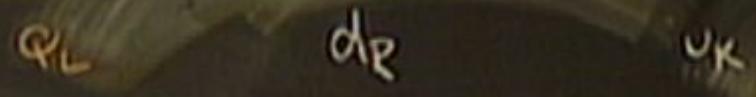
$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} \left(2 \cdot 3 \cdot \frac{1}{3} - 3 \cdot \frac{1}{3} - 3 \cdot \frac{1}{3} \right) = 0$$



$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} \left(3 \cdot 3 \cdot \frac{1}{3} \right) = \frac{3}{2}$$



$$A^{SM}(U(1)_Y U(1)_B^2) = \left[2 \cdot \frac{1}{6} \cdot 3 \cdot 3 \cdot \frac{1}{9} - \left(-\frac{1}{3} \right) 3 \cdot 3 \cdot \frac{1}{9} - \left(\frac{2}{3} \right) 3 \cdot 3 \cdot \frac{1}{9} \right] = 0$$



$$A(U(1)_Y^2 U(1)_B) = \left\{ \right.$$

Anomaly Cancel (Barren)

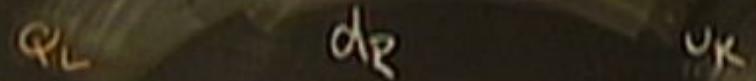
$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} (2 \cdot 3 \cdot \frac{1}{3} - 3 \cdot \frac{1}{3} - (3 \frac{1}{3})) = 0$$



$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} (3 \cdot 3 \cdot \frac{1}{3}) = \frac{3}{2}$$



$$A^{SM}(U(1)_A^2 U(1)_B) = [2 \cdot \frac{1}{6} \cdot 3 \cdot 3 \cdot \frac{1}{9} - (\frac{-1}{3}) \cdot 3 \cdot 3 \cdot \frac{1}{9} - (\frac{2}{3}) \cdot 3 \cdot 3 \cdot \frac{1}{9}] = 0$$



$$A(U(1)_A^2 U(1)_B) = [2 (\frac{1}{36}) \cdot 3 \cdot 3 \cdot \frac{1}{3} - \frac{1}{9} \cdot 3 \cdot 3 \cdot \frac{1}{3} - \frac{4}{4} \cdot 3 \cdot 3 \cdot \frac{1}{3}] = -3/2$$

Anomaly Cancel (Barin)

$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} \left(\overset{\substack{\uparrow \\ T_A T_B}}{2 \cdot 3 \cdot \frac{1}{3}} - \overset{\uparrow}{3 \cdot \frac{1}{3}} - \overset{dk}{\left(3 \cdot \frac{1}{3} \right)} \right) = 0$$

$$A^{SM}(SU(3)^2 U(1)_B) = \frac{1}{2} \left(\overset{\substack{\uparrow \\ Q_L}}{3 \cdot 3 \cdot \frac{1}{3}} \right) = \boxed{\frac{3}{2}}$$

$$A^{SM}(U(1)_Y^2 U(1)_B) = \left[\overset{Q_L}{2 \cdot \frac{1}{6} \cdot 3 \cdot 3 \cdot \frac{1}{9}} - \overset{d_R}{\left(\frac{1}{3} \right) 3 \cdot 3 \cdot \frac{1}{9}} - \overset{u_R}{\left(\frac{2}{3} \right) 3 \cdot 3 \cdot \frac{1}{9}} \right] = 0$$

$$A(U(1)_Y^2 U(1)_B) = \left[\overset{Q_L}{2 \cdot \left(\frac{1}{3c} \right) 3 \cdot 3 \cdot \frac{1}{3}} - \overset{d_R}{\frac{1}{9} 3 \cdot 3 \cdot \frac{1}{3}} - \overset{u_R}{\frac{4}{9} 3 \cdot 3 \cdot \frac{1}{3}} \right] = \boxed{-\frac{3}{2}}$$

$$A(S_{U(2)}^2 U(1)) = \boxed{\frac{3}{2}}$$

$$A(U(1)_Y^2 U(1)_L) = \boxed{-\frac{3}{2}}$$

$\Theta(U)_Y$

$$L = (1, 2, -1/2; 0, 1)$$

$$R = (1, 1, -1/3; 0, 1)$$

$$R' = (1, 1, 0; 0, 1)$$

$\Theta(U)$

$$\frac{d\sigma/d\Omega}{\Lambda^2}$$

$$\tau_P / \text{Br}(P \rightarrow \pi^0 e^+ e^-) > 1.6 \times 10^{13} \text{ yr}$$

$\Lambda \gtrsim 10^{16} \text{ GeV}$ limit

$$g(L \rightarrow H)(L \rightarrow H)$$

$$m_\nu \sim g v^2 / \Lambda$$

$$\begin{aligned}
 \vec{r}_1 &= (1, 2, -\frac{1}{2}, 0, 1) \\
 \vec{r}_2 &= (1, 1, -1, 0, 1) \\
 \vec{r}_3 &= (1, 1, 0, 0, 1) \\
 & \quad (\frac{1}{2}, 0, 0)
 \end{aligned}$$



Φ'

ψ'

d.

Γ

θ

\sim

(1) γ

math / 0003075

$$r_1 = (1, 2, -\frac{1}{2}, 0, 1)$$

$$r_2 = (1, 1, -1, 0, 1)$$

$$r_3 = (1, 1, 0, 0, 1)$$

$$\frac{1}{2}, 0, 0)$$

$$Q'_R = I$$

$$U'_L =$$

$$d'_L =$$

$$L'_R =$$

$$e'_L =$$

$$z'_L =$$

$$A^{SM}(\text{SU}(2) \cup (1)_B) = \frac{1}{2} \left(\overset{3}{\underbrace{\quad}_{Q_L}} \cdot \overset{3}{\underbrace{\quad}_{\text{color}}} \cdot \frac{1}{3} \right) = \boxed{\frac{3}{2}}$$

$$A^{SM}(\cup (1)_Y \cup (1)_B^2) = \left[2 \frac{1}{6} \cdot 3 \cdot 3 \frac{1}{9} - \left(\frac{-1}{3} \right) 3 \cdot 3 \frac{1}{9} - \left(\frac{2}{3} \right) 3 \cdot 3 \frac{1}{9} \right]$$

$$A(\cup (1)_Y^2 \cup (1)_B) = \left[2 \left(\frac{1}{3C} \right) \overset{3}{\underbrace{\quad}_{Q_L}} \cdot 3 \cdot 3 \cdot \frac{1}{3} - \frac{1}{9} 3 \cdot 3 \frac{1}{3} - \frac{4}{9} 3 \cdot 3 \frac{1}{3} \right]$$

$$A^{-1}(U(1)_Y \cup U(1)_B) = \left[2 \frac{1}{6} \cdot 5 \cdot 3 \frac{1}{4} - \left(\frac{-1}{3} \right) 3 \cdot 3 \frac{1}{4} - \left(\frac{2}{5} \right) 3 \cdot 3 \frac{1}{4} \right] = 0$$

$$A(U(1)_Y^2 \cup U(1)_B) = \left[2 \left(\frac{1}{3c} \right) 3 \cdot 3 \cdot \frac{1}{3} - \frac{1}{9} 3 \cdot 3 \frac{1}{3} - \frac{4}{9} 3 \cdot 3 \frac{1}{3} \right] = \boxed{-3/2}$$

$$A(\dots)$$

$$A(\dots)$$

(2) $\cup \cup \cup$

$\cup \cup \cup$
 $(0, 1, 0, 1)$

$$\left. \begin{aligned} L_L^i &= (1, 2, -\frac{1}{2}; 0, 1) \\ e_R^i &= (1, 1, -1; 0, 1) \\ d_R^i &= (1, 1, 0; 0, 1) \end{aligned} \right\}$$

$$(1, 2, \frac{1}{2}; 0, 0)$$

$$Q_R^i = (3, 2, \frac{1}{2}; 1, 0)$$

$$U_L^i = (3, 1, \frac{1}{2}; 1, 0)$$

$$d_L^i = (3, 1, -\frac{1}{2}; 1, 0)$$

$$L_R^i = (1, 2, -\frac{1}{2}; 0, 3)$$

$$e_L^i = (1, 1, -1; 0, 3)$$

$$V_L^i = (1, 1; 0; 0, 3)$$

$$A(SU(2) \cup U(1)_B) = \frac{1}{2} \left(\underbrace{3}_{Q_L} \cdot \underbrace{3}_{Q_L} \cdot \underbrace{1/3}_{U(1)_B} \right) = \boxed{\frac{3}{2}}$$

$$A^{SM}(U(1)_Y \cup U(1)_B^2) = \left[2 \cdot \frac{1}{6} \cdot 3 \cdot 3 \cdot \frac{1}{9} - \left(\frac{-1}{3} \right) 3 \cdot 3 \cdot \frac{1}{9} - \left(\frac{2}{3} \right) 3 \cdot 3 \cdot \frac{1}{9} \right] = 0$$

$$A(U(1)_Y^2 \cup U(1)_B) = \left[2 \cdot \left(\frac{1}{3c} \right) \cdot 3 \cdot 3 \cdot \frac{1}{3} - \frac{1}{9} \cdot 3 \cdot 3 \cdot \frac{1}{3} - \frac{4}{9} \cdot 3 \cdot 3 \cdot \frac{1}{3} \right] = \boxed{-\frac{3}{2}}$$

$$A(SU(2)^2 \cup U(1)) = \boxed{\frac{3}{2}}$$

$$A(U(1)_Y^2 \cup U(1)_L) = \boxed{-\frac{3}{2}}$$

$$SU(2)_c \times SU(2) \times U(1)_Y \times U(1)$$

$$\left((SU(3)_C, SU(3)_F, U(1)_1, U(1)_2, U(1)_3) \right)$$

$$\left. \begin{aligned} Q_L^i &= (3, 2, \frac{1}{6}, \frac{1}{3}, 0) \\ U_R^i &= (3, 1, \frac{2}{3}, \frac{1}{3}, 0) \\ d_R^i &= (3, 1, -\frac{1}{3}, \frac{1}{3}, 0) \end{aligned} \right\} \begin{aligned} L_L^i &= (1, 2, -\frac{1}{2}, 0, 1) \\ e_R^i &= (1, 1, -1, 0, 1) \\ \nu_R^i &= (1, 1, 0, 0, 1) \end{aligned}$$

$$H = (1, 2, \frac{1}{2}, 0, 0)$$

$$Q_R^i = (3, 2, \frac{1}{6}, 1, 0)$$

$$U_L^i = (3, 1, \frac{2}{3}, 1, 0)$$

$$d_L^i = (3, 1, -\frac{1}{3}, 1, 0)$$

$$L_R^i = (1, 2, -\frac{1}{2}, 0, 3)$$

$$e^i = (1, 1, -1, 0, 3)$$

$$\nu_L^i = (1, 1, 0, 0, 3)$$

$$H = (1, 2, \frac{1}{2}; 0, 0)$$

$$L'_R = (1, 2, \frac{1}{2}; 0, 3)$$

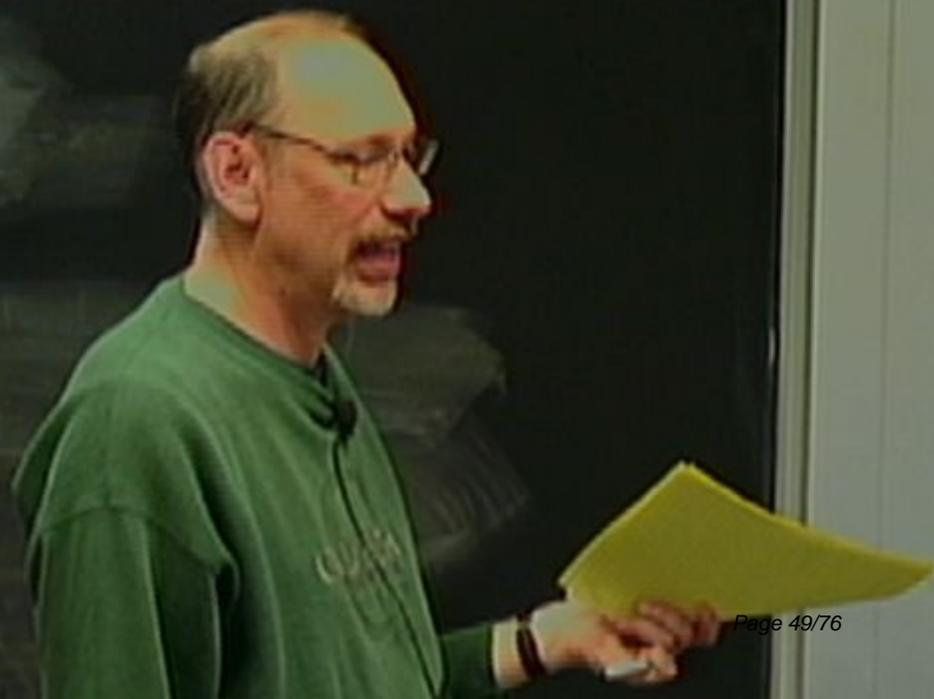
$$e'_R = (1, 1, -1; 0, 3)$$

Pavel Filviez Perez, MTSW

arXiv: 1802.1754v2

- 1) What do we love (about the standard model)
- 2) Gauge. By L Anomaly cancellation
- 3) Lagrange Density gauge sector
- 4) " " lepton sector

$$\begin{aligned}
 & (3, 1, -1, 0, 1) \\
 & (3, 1, -1, 0, 1) \\
 & H = (1, 2, \frac{1}{2}; 0, 0) \\
 & \left. \begin{aligned}
 & \gamma_R = (1, 1, 0; 0, 1) \\
 & \gamma_L = (1, 1, 0; 0, 1)
 \end{aligned} \right\} \\
 & d'_L = (3, 1, -1, 0, 1) \\
 & L'_{R2} = (1, 2, \frac{1}{2}; 0, 3) \\
 & e'_L = (1, 1, -1, 0, 3) \\
 & v'_L = (1, 1, 0; 0, 3) \\
 & + \text{New Scals } S, S_0, X
 \end{aligned}$$



+ New Sculls μ, σ, X

Degradation

$$S = 0$$

$$T = 0$$

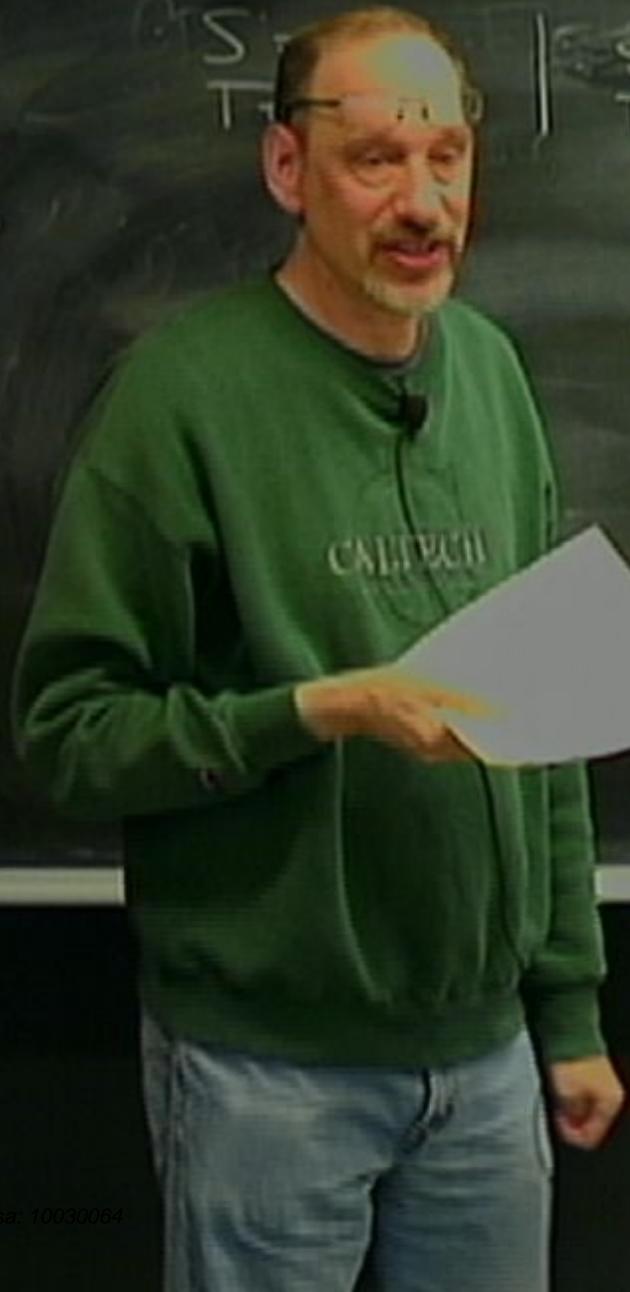
$$S = 0.03 \pm 0.10$$

+ New Sculs ϕ, S_{II}, X

Degrad

S
T

$$S = 0.03 \pm 0.10$$
$$T = 0.07 \pm 0.08$$



+ New Sculs μ, σ, X

Demost

$$S = 0.03 \pm 0.110$$
$$T = 0.07 \pm 0.08$$

N

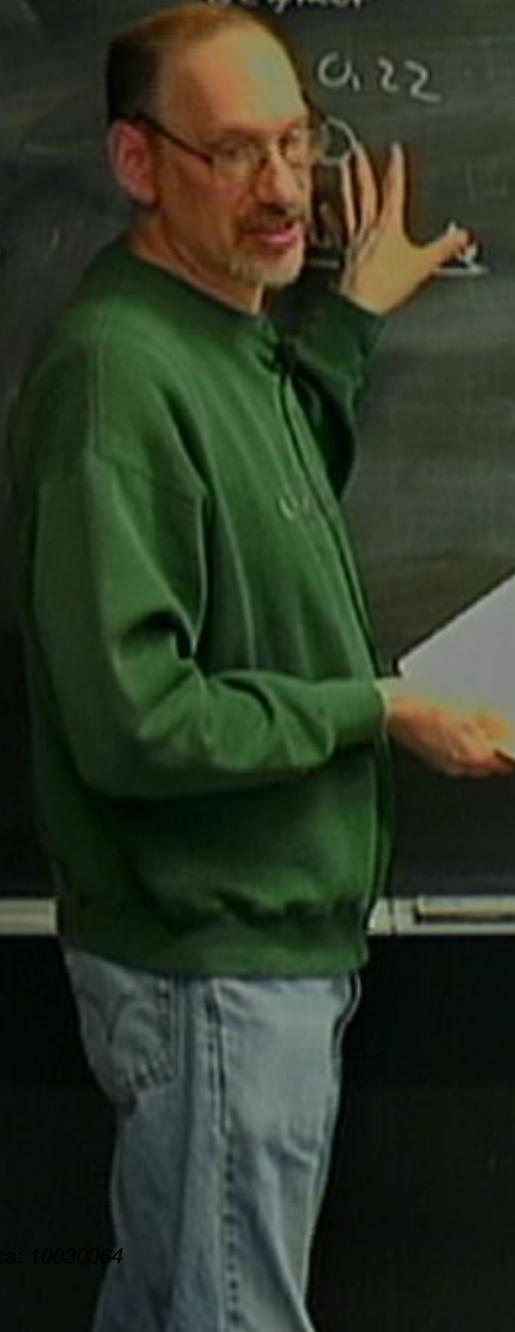
CAUTION

+ New Scals ϕ, S_u, X

Degrade

0.22

$$S = 0.03 \pm 0.110$$
$$T = 0.07 \pm 0.08$$



+ New Scals S_{II}, X

Degrade

$$S = 0.22$$
$$T = 0$$

$$S = 0.03 \pm 0.10$$
$$T = 0.07 \pm 0.08$$

Non degenerate

$$T=0$$

$$T=0.05 \pm 0.10$$
$$T=0.07 \pm 0.08$$

Non degenerate

Quark Sector

$$-\Delta \mathcal{L}_{q' \text{-mass}} = Y_U' \overline{Q}_R' H^+ u_R' + Y_D' \overline{Q}_R' H d_L + \text{h.c.}$$

$$T=0$$

$$T=0.05 \pm 0.10$$
$$T=0.07 \pm 0.08$$

Non degenerate

Quark Sector

$$-\Delta \mathcal{L}_{q\text{-mass}} = Y_U \overline{Q}_R H^+ U_R + Y_D \overline{Q}_R H^0 D_L + \text{h.c.}$$

$$T=0 \quad | \quad T=0.07 \pm 0.08$$

Non degenerate

Quark Sector

$$-\Delta \mathcal{L}_{g'-mass} = Y_U'' \bar{Q}_R' H^+ u_R' + Y_D \bar{Q}_R' H d_L + h.c.$$

Add a complex scalar (NO VEV) $X \sim (1, 1, 0; -2/3, 0)$

$\Gamma = 0$ $\Gamma = 0.07 \pm 0.08$

Non degenerate

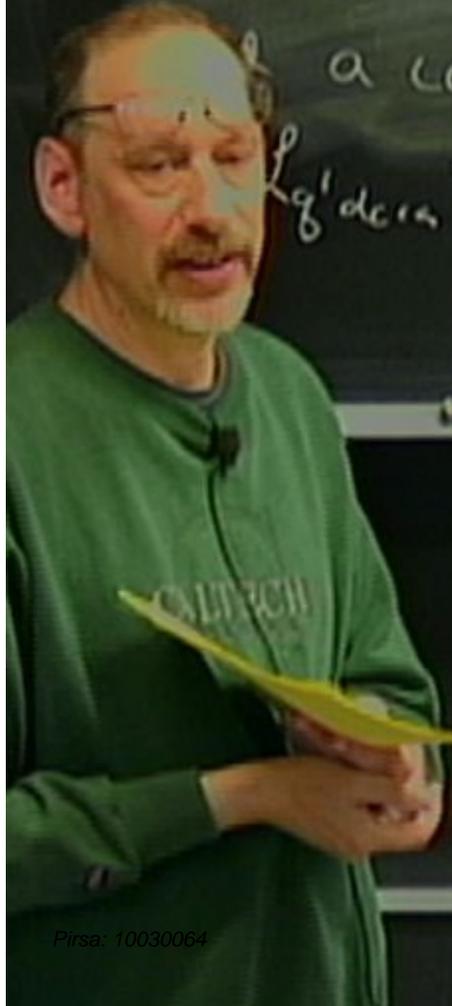
Quark Sector

$$-\Delta S_{g'-mass} = Y_U' \overline{Q_R'} H^+ u_R' + Y_D' \overline{Q_R'} H d_L + h.c.$$

a complex scalar (NO VEV) $X \sim (1, 4, 0, -2/3, 0)$

$$L_{g'dem} = \lambda_a \overline{Q_L} Q_R'$$

$-\frac{2}{3}$	$-\frac{1}{3}$	1
----------------	----------------	---



$\Gamma = 0$ $\Gamma = 0.07 \pm 0.08$

Non degenerate

Quark Sector

$$-\Delta \mathcal{L}_{g'-mass} = Y_U' \overline{Q_R'} H^+ U_R'' + Y_D \overline{Q_R'} H d_L + h.c.$$

Add a scalar (NO VEV) $X \sim (1, 1, 0, -2/3, 0)$

$$-\Delta \mathcal{L} \propto \overline{Q_L} \begin{pmatrix} -2/3 \\ -1/3 \\ 1 \end{pmatrix} Q_R' +$$

Non degenerate

Quark Sector

$$-\Delta \mathcal{L}_{g'-mass} = Y_U'' \bar{Q}_R' H^+ u_R'' + Y_D \bar{Q}_R' H d_L + h.c.$$

Add a complex scalar (NO VEV) $X \sim (1, 1, 0, -2/3, 0)$

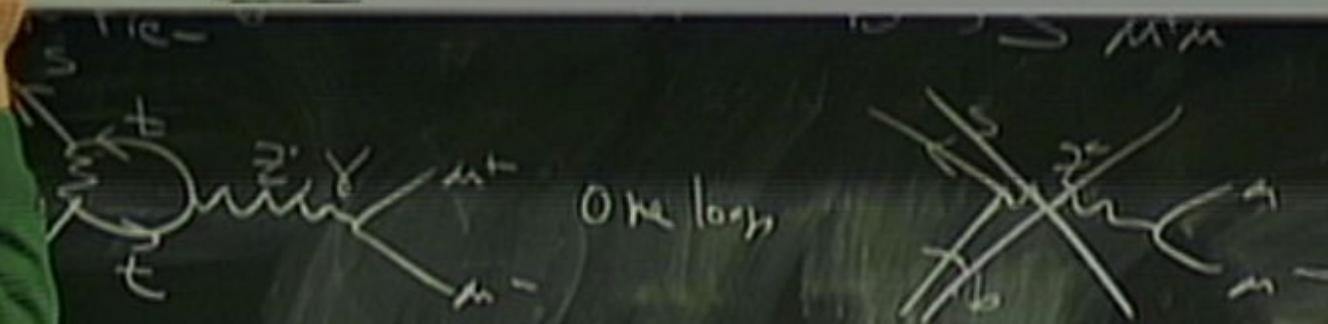
$$\mathcal{L}'_{dec} = \lambda_a \bar{Q}_L \begin{pmatrix} -2/3 \\ -1/3 \\ 1 \end{pmatrix} Q_R' + \lambda_U X \bar{U}_R U_L'' + \lambda_D X \bar{D}_R d_L''$$

$$= \Delta \mathcal{L}_{y=mass} = Y_U' \overline{Q_R'} H^+ u_R' + Y_D \overline{Q_R'} H d_L + h.c.$$

Add a complex scalar (NO VEV) $X \sim (1, 1, 0, -1/3, 0)$

$$-\Delta \mathcal{L}_{g'_{dec}} = \lambda_a X \overline{Q_L} Q_R' + \lambda_U X \overline{U_R} U_L' + \lambda_D X \overline{D_R} d_L'$$

$\begin{matrix} \frac{2}{3} & -\frac{1}{3} & 1 \end{matrix}$



$$H = (1, \sqrt{2}, 0, 0)$$

$$L_R = (1, \sqrt{2}, 0, 0)$$

$$E_L = (1, 1, -1, 0)$$

Degenerate

$$S = 0.22$$

$$T = 0$$

$$S = 0.03 \pm 0.10$$

$$T = 0.07 \pm 0.08$$

Non degenerate

Quark Sector

$$-\Delta \mathcal{L}_{g'-mass} = Y_U \bar{Q}_R' H^+ u_R' + Y_D \bar{Q}_R' H^0 d_L + h.c.$$

Add a complex scalar (NO VEV) $X \sim (1, 1, 0, -2/3, 0)$

$$-\Delta \mathcal{L}_{g'dera} = \lambda_a \bar{Q}_L \begin{matrix} -2/3 \\ -1/3 \\ 1 \end{matrix} Q_R' + \lambda_U \bar{U}_R U_L' + \lambda_D \bar{D}_R d_L'$$

A

$$U' d' \rightarrow \bar{X} \cup d$$

$$(a'_n, U'_L, d'_L) \rightarrow e^{i, \lambda} (a'_n, U'_R, d'_R)$$

$$x \rightarrow e^{-i, \lambda} x$$

A

$$v' d' \rightarrow \bar{X} \cup d$$

$$(a'_n, v'_L, d'_L) \rightarrow e^{i\alpha} (a'_n, v'_R, d'_R)$$

$$x \rightarrow e^{-i\alpha} x$$

A

$$U' d' \rightarrow X \cup d$$

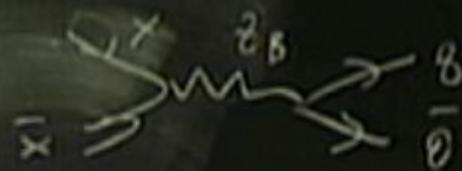


$$(a'_n, U'_L, d'_L) \rightarrow e^{i\alpha} (a''_n, U''_R, d''_n)$$

$$x \rightarrow e^{-i\alpha} x$$

A

$$U' d' \rightarrow \bar{X} \cup d$$



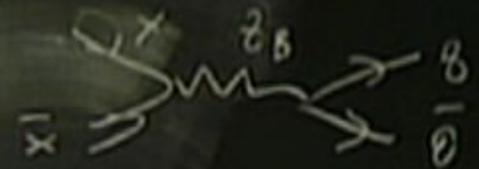
$$(q'_n, u'_n) \rightarrow e^{i\lambda} (q_n, u_n, d_n)$$

$$\lambda X^* X H^+ H$$

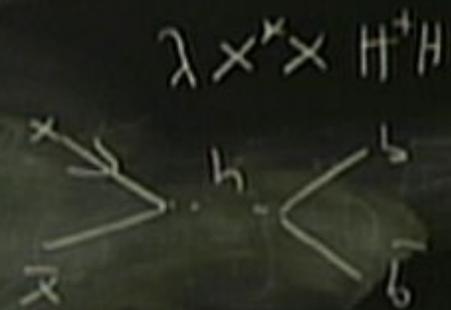
X X

A

$$u' d' \rightarrow \bar{X} u d$$

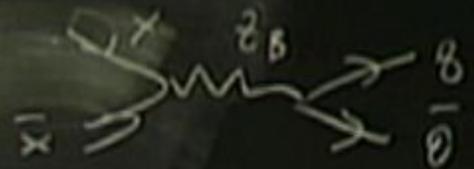


$$(u_L', d_L') \rightarrow e^{i\alpha} (u_R', d_R')$$
$$\rightarrow e^{-i\alpha} X$$



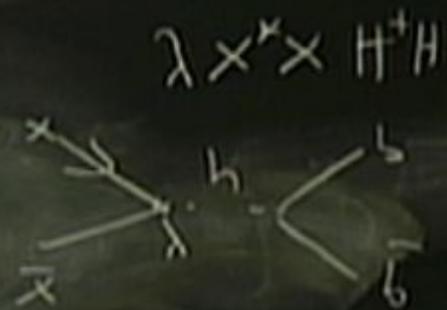
A

$$u' d' \rightarrow \bar{X} u d$$



$$(q'_n, u'_L, d'_L) \rightarrow e^{i\alpha} (q''_n, u''_R, d''_R)$$

$$X \rightarrow e^{-i\alpha} X$$



$$S = 0.12$$

$$T = 0$$

$$S = 0.03 \pm 0.10$$

$$T = 0.07 \pm 0.08$$

Non deca

Quark S

$-\Delta S_{gl}$

$$Y_U \overline{Q_R'} H^+ U_R' + Y_D \overline{Q_R'} H^0 d_L + h.c.$$

A

Complex scalar (no VEV) $X \sim (1, 4, 0, -1/3, 0)$

$$-\lambda_e X \overline{Q_L} Q_R' + \lambda_U X \overline{U_R} U_L' + \lambda_D X \overline{d_R} d_L'$$

Demond

$$S = 0.22 \\ T = 0$$

$$S = 0.03 \pm 0.110 \\ T = 0.07 \pm 0.08$$

Neutrino

Q_{ν}

$-\Delta S$

$$Y_U \bar{Q}_L' H^+ U_R' + Y_D \bar{Q}_R' H^0 d_L + h.c.$$

$$X \sim (1, 1, 0, -1/3, 0) \quad (\text{no VEV})$$

$$X \bar{Q}_L' Q_R' + \lambda_U X \bar{U}_R' U_L' + \lambda_D X \bar{d}_R' d_L'$$

$$\begin{matrix} -2/3 & -1/3 & 1 \end{matrix}$$

Degrad

$$\begin{array}{l|l} S = 0.22 & S = 0.03 \pm 0.110 \\ T = 0 & T = 0.07 \pm 0.08 \end{array}$$

$s_1 \approx 0$

Non degenerate

Quark Sector

$$-\Delta \mathcal{L}_{q-mass} = Y_U' \bar{Q}_R' H^+ u_L' + Y_D \bar{Q}_R' H^0 d_L + h.c.$$

Add a complex scalar (no VEV) $X \sim (1, 1, 0, -1/3, 0)$

$$-\Delta \mathcal{L}_{g'dem} = \lambda_a X \begin{array}{c} \bar{Q}_L \\ -2/3 \\ -1/3 \\ 1 \end{array} Q_R' + \lambda_U X \bar{U}_R U_L' + \lambda_D X \bar{d}_R d_L'$$



A

$$\Delta \frac{1}{R} \frac{1}{z}$$

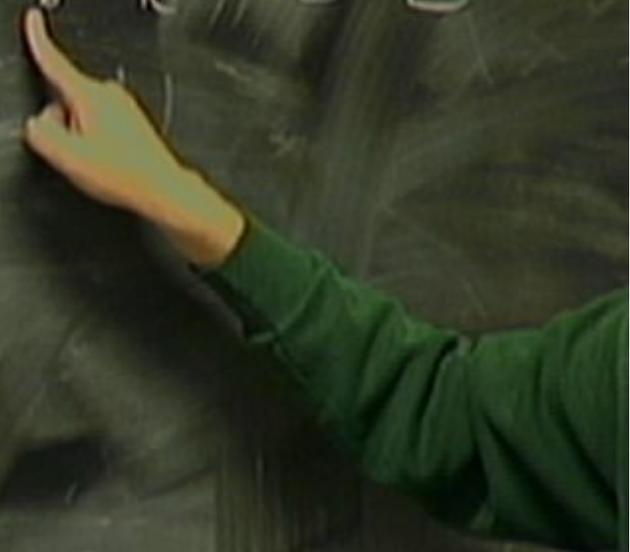
21

$$\Delta \mathcal{L}_V = \bar{\psi}_V \left[\overline{L}_R \not{H} \psi_L + Y_V L_L \not{H} \psi_R \right. \\ \left. + \frac{\lambda_5}{2} \psi_R^c S_L \psi_R^c + \lambda_6 \overline{\psi}_R^c S_L^+ \psi_L \right]$$

$$S_L = (1, 1, 0; 0, 2)$$

$$\Delta \mathcal{L}_V = Y_\nu \overline{L}_R H^* \nu_L + Y_\nu L_L H \nu_R + \frac{\lambda_a}{2} \nu_R^c S_L \nu_R^c + \lambda_b \overline{\nu}_R^c S_L^+ \nu_L^c$$

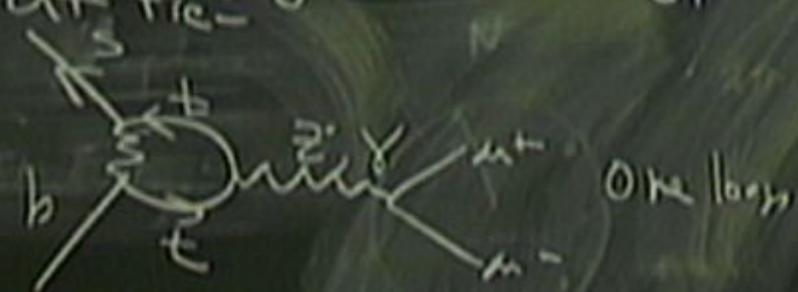
$$S_L = (1, 1, 0; 0, 2)$$



$$\Delta \mathcal{L}_V = \bar{\psi}_V \overline{L}_R H^* \psi_L + \bar{\psi}_V L_L H \psi_R + \frac{\lambda_5}{2} \bar{\nu}_R^c S_L \nu_R^c + \lambda_6 \bar{\nu}_R^c S_L^+ \psi_L$$

$$S_L = (1, 1, 0; 0, 2)$$

N.
 Flavor changing neutral currents
 at tree



$b \rightarrow s$ $\mu^+ \mu^-$

