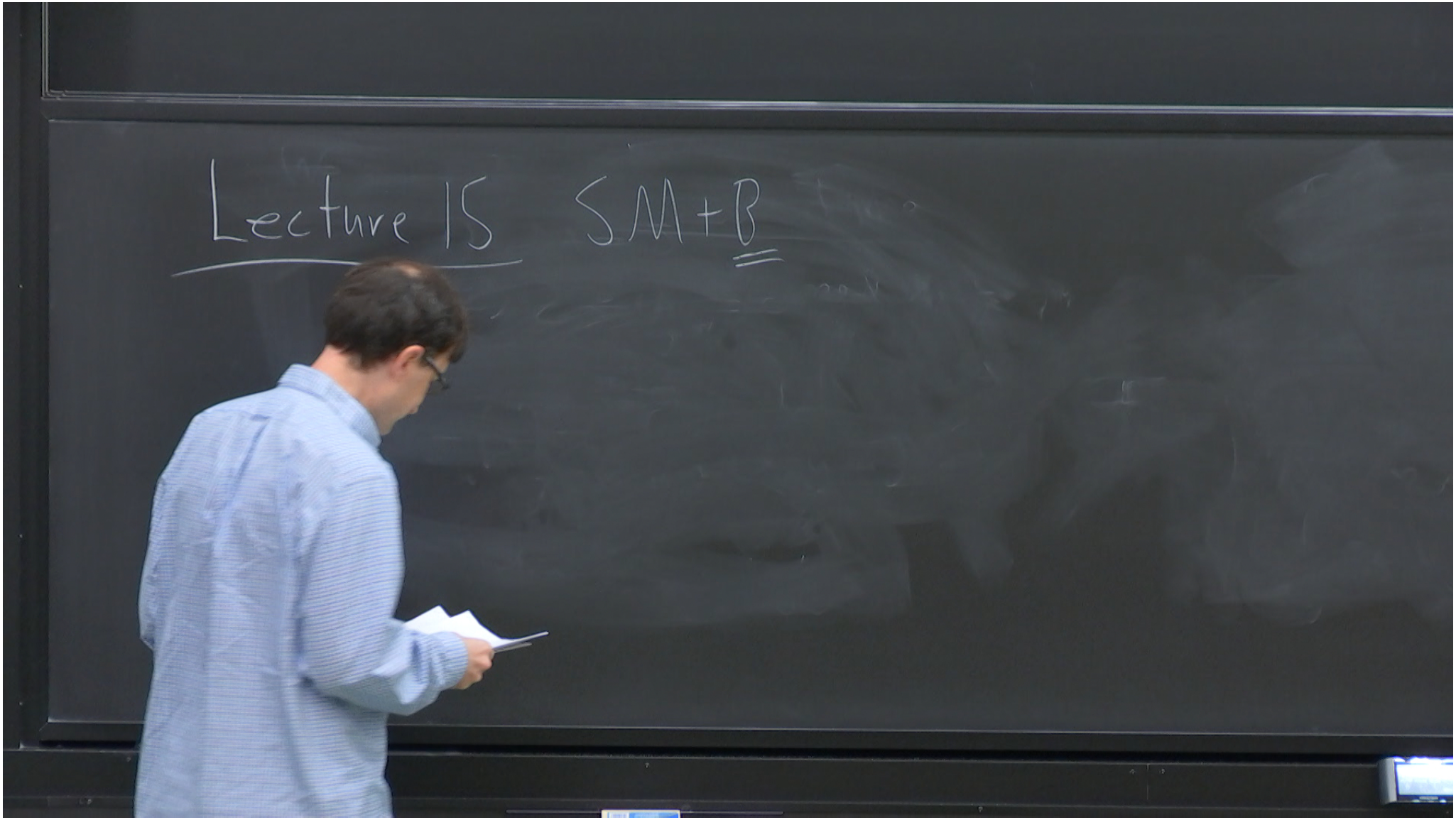
Title: PSI 2019/2020 - Standard Model and Beyond part 2 - Lecture 3

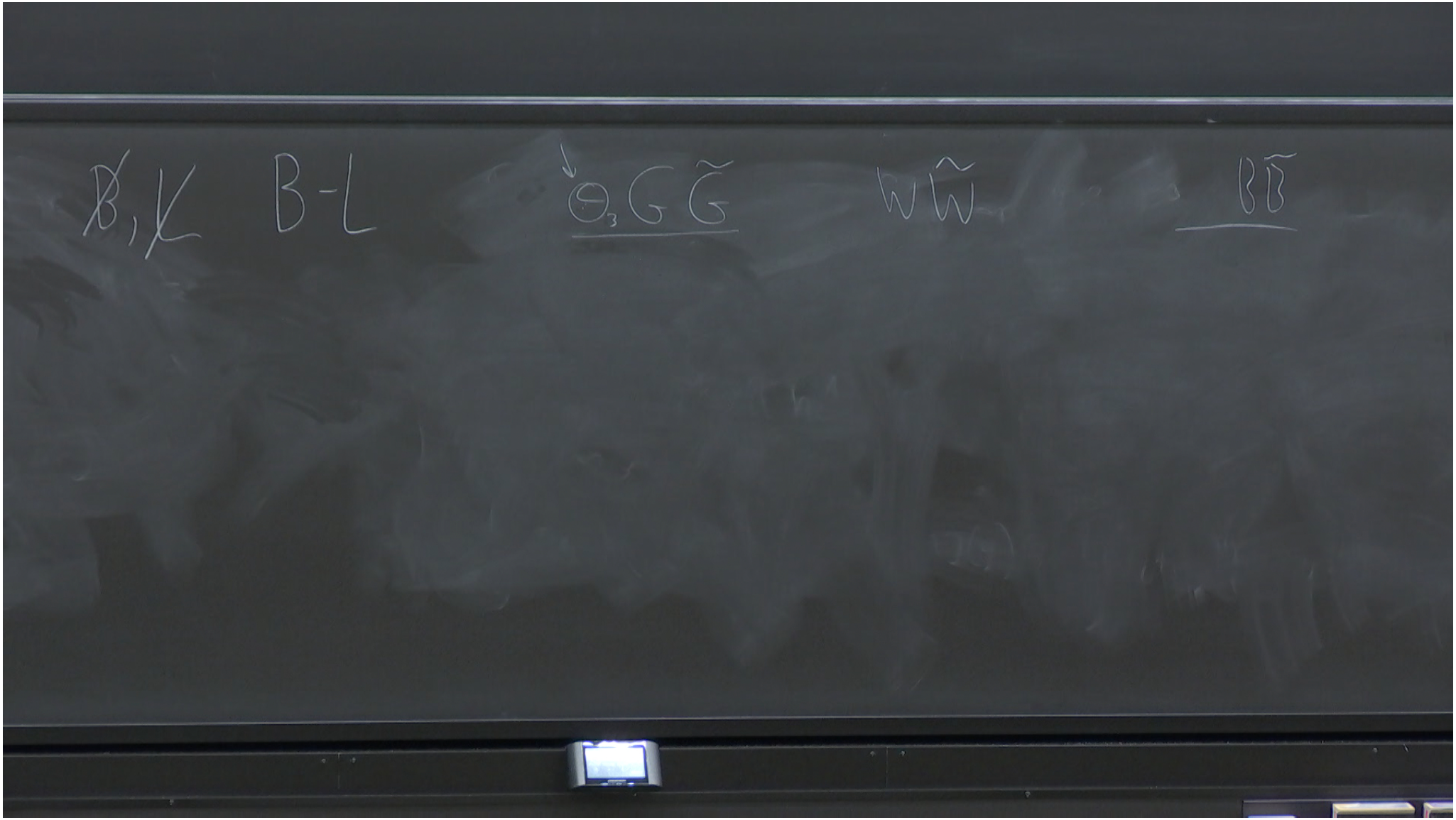
Speakers: Latham Boyle

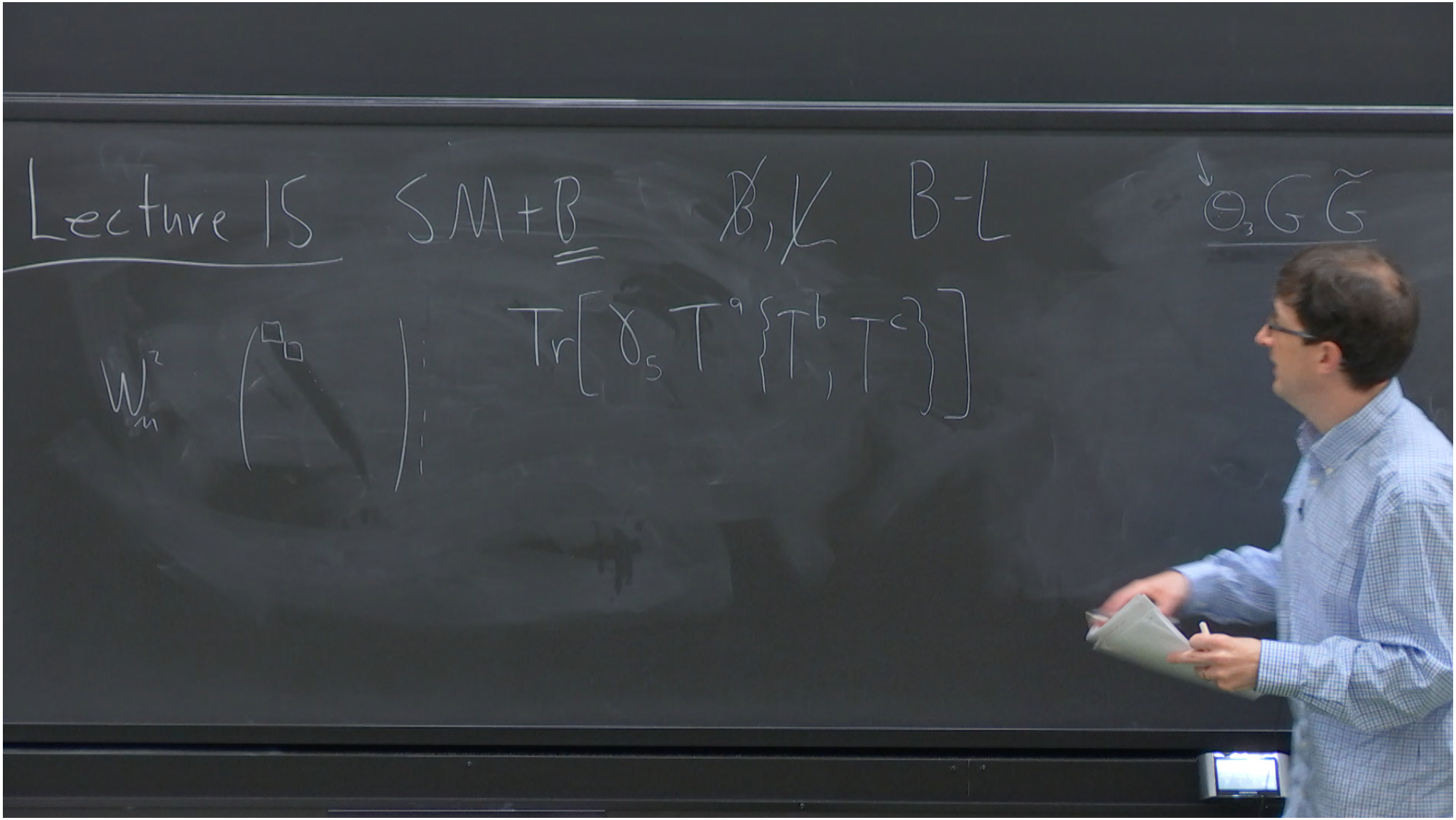
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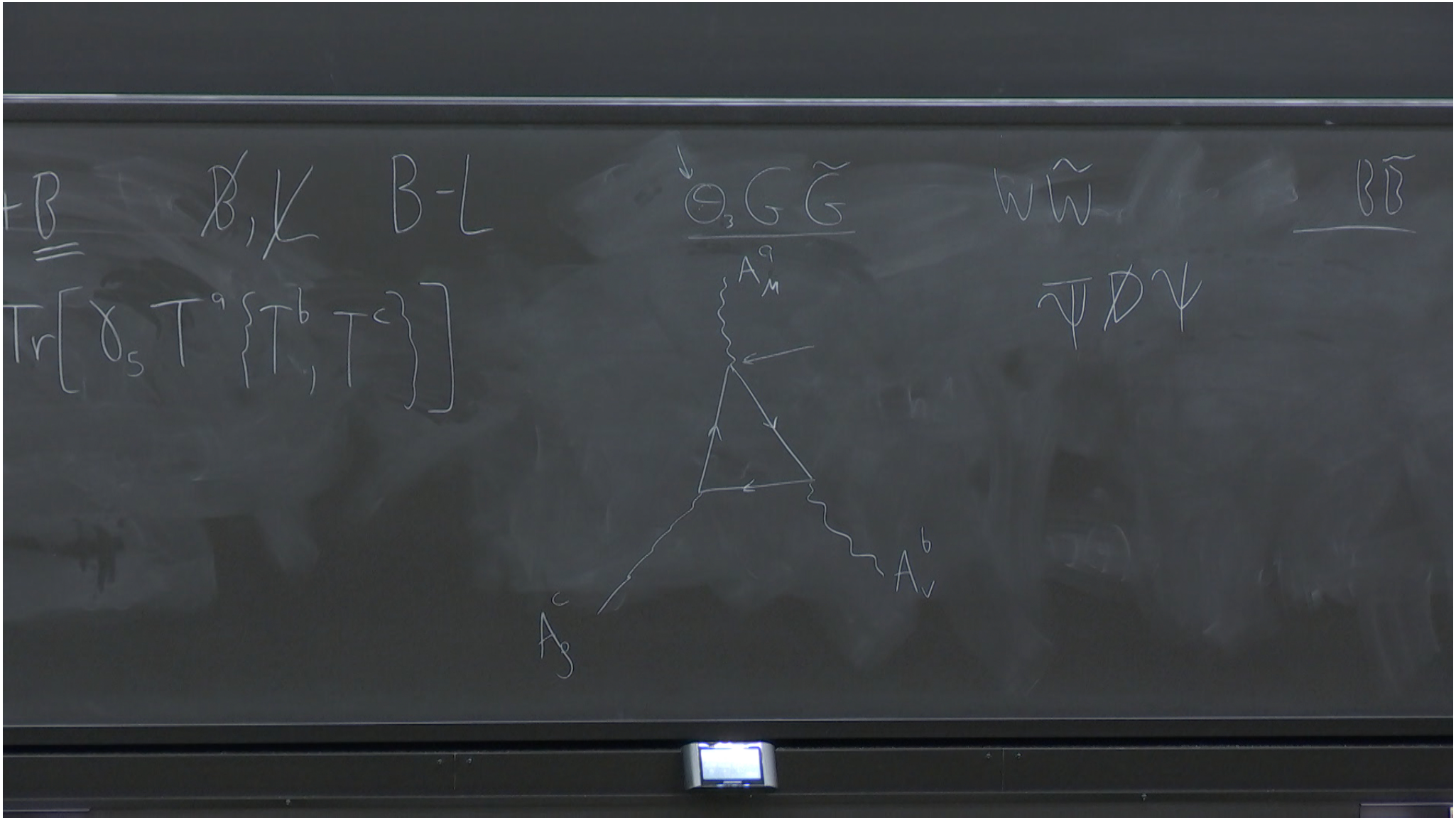
Date: February 24, 2020 - 11:15 AM

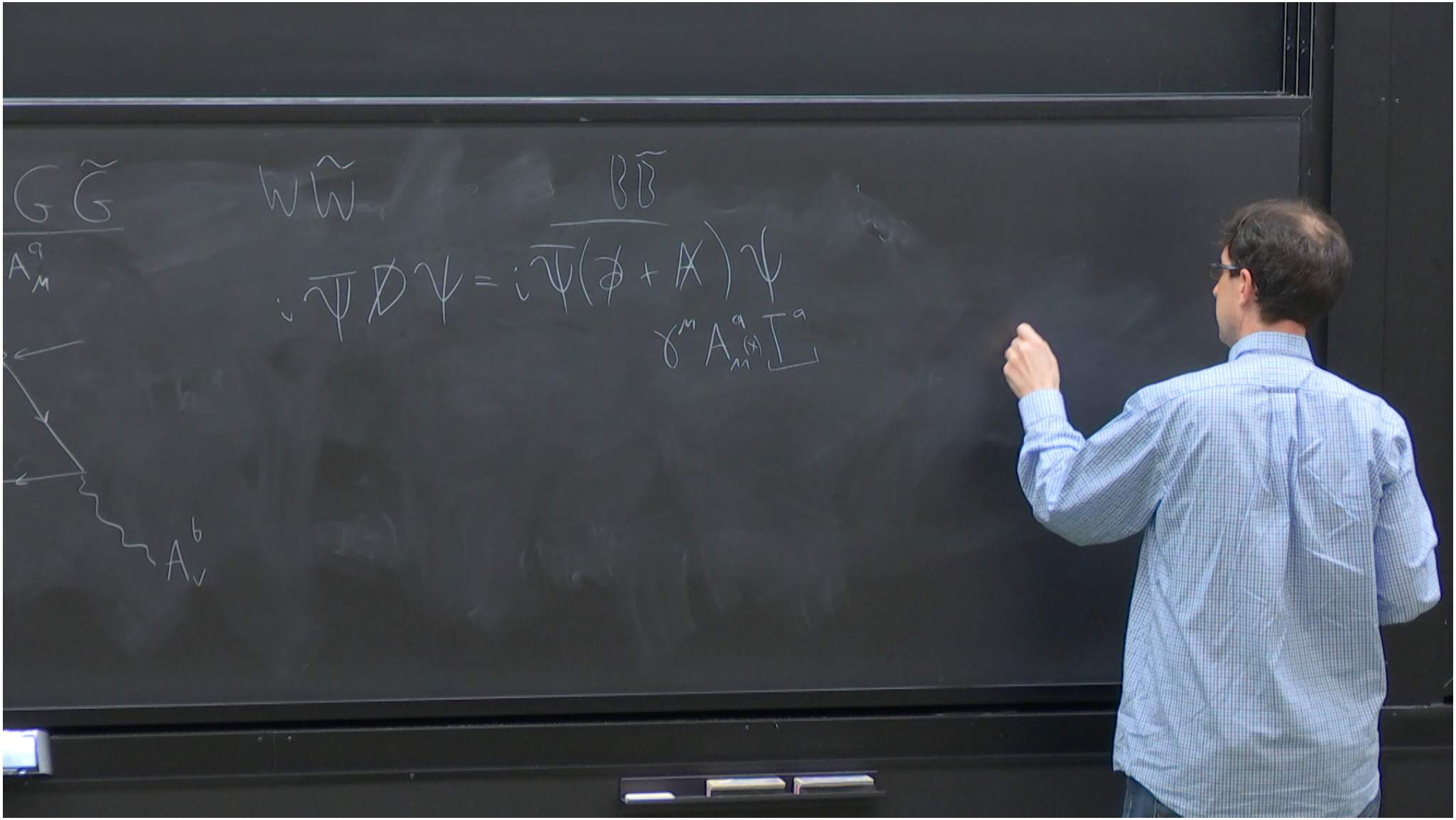
URL: http://pirsa.org/20030039


Lecture 15 SM+β


B, L
B-L
$\theta_3 G\tilde{G}$
$W\tilde{W}$
$B\tilde{B}$


Lecture 15
SM+β
B, L
B-L
$\theta_3 G\tilde{G}$
W_μ^2
$\mathrm{Tr}[\gamma_5 T^a \{T^b, T^c\}]$

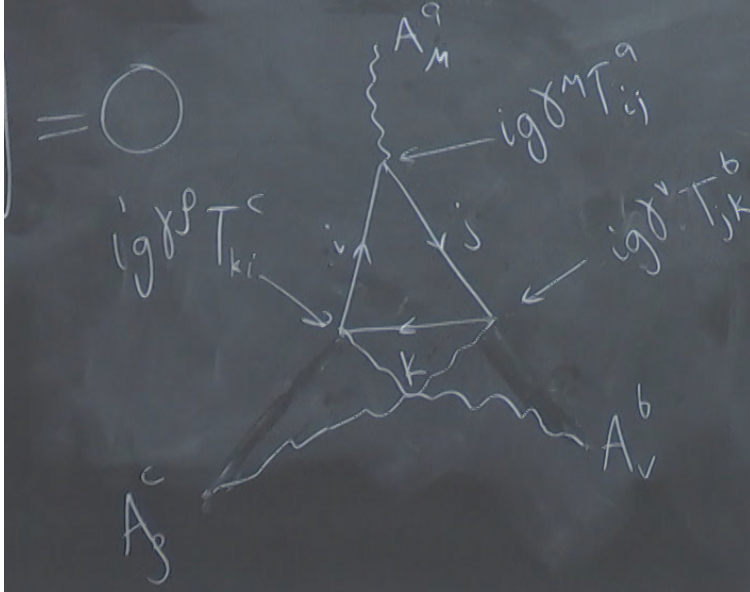

+B
B, L
B-L
$\theta_3 G\tilde{G}$
$W\tilde{W}$
$B\tilde{B}$
$\mathrm{Tr}[\gamma_5 T^a \{T^b, T^c\}]$
$\bar{\psi} \not{D} \psi$
A^a_μ
A^b_ν
A^c_ρ

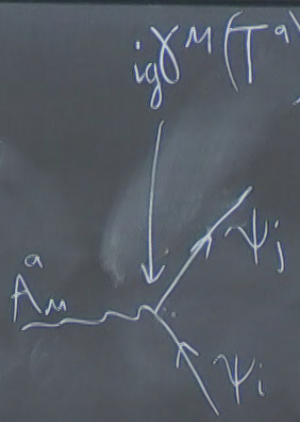

$G\tilde{G}$
$W\tilde{W}$
$B\tilde{B}$
A^a_μ
$i\bar{\psi}\not{D}\psi = i\bar{\psi}(\not{\partial} + \not{A})\psi$
$\gamma^\mu A^a_\mu(x) T^a$
A^b_ν

$\theta_3 G\tilde{G}$ $\quad w\tilde{w}$ $\quad \beta\tilde{\beta}$

$i\bar{\psi}\not{D}\psi = i\bar{\psi}_i(\not{\partial} + g\not{A})\psi^j$

$\gamma^\mu A^a_\mu (T^a)^i_j$





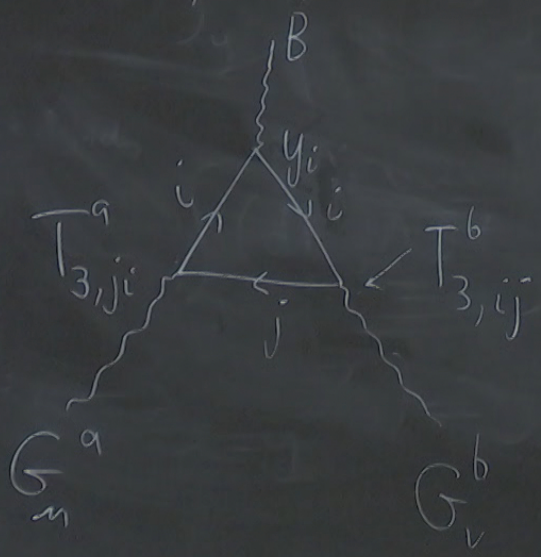
$T^a_{ij} T^b_{jk} T^c_{ki} = Tr[T^a T^b T^c]$

$Tr[T^a T^c T^b]$

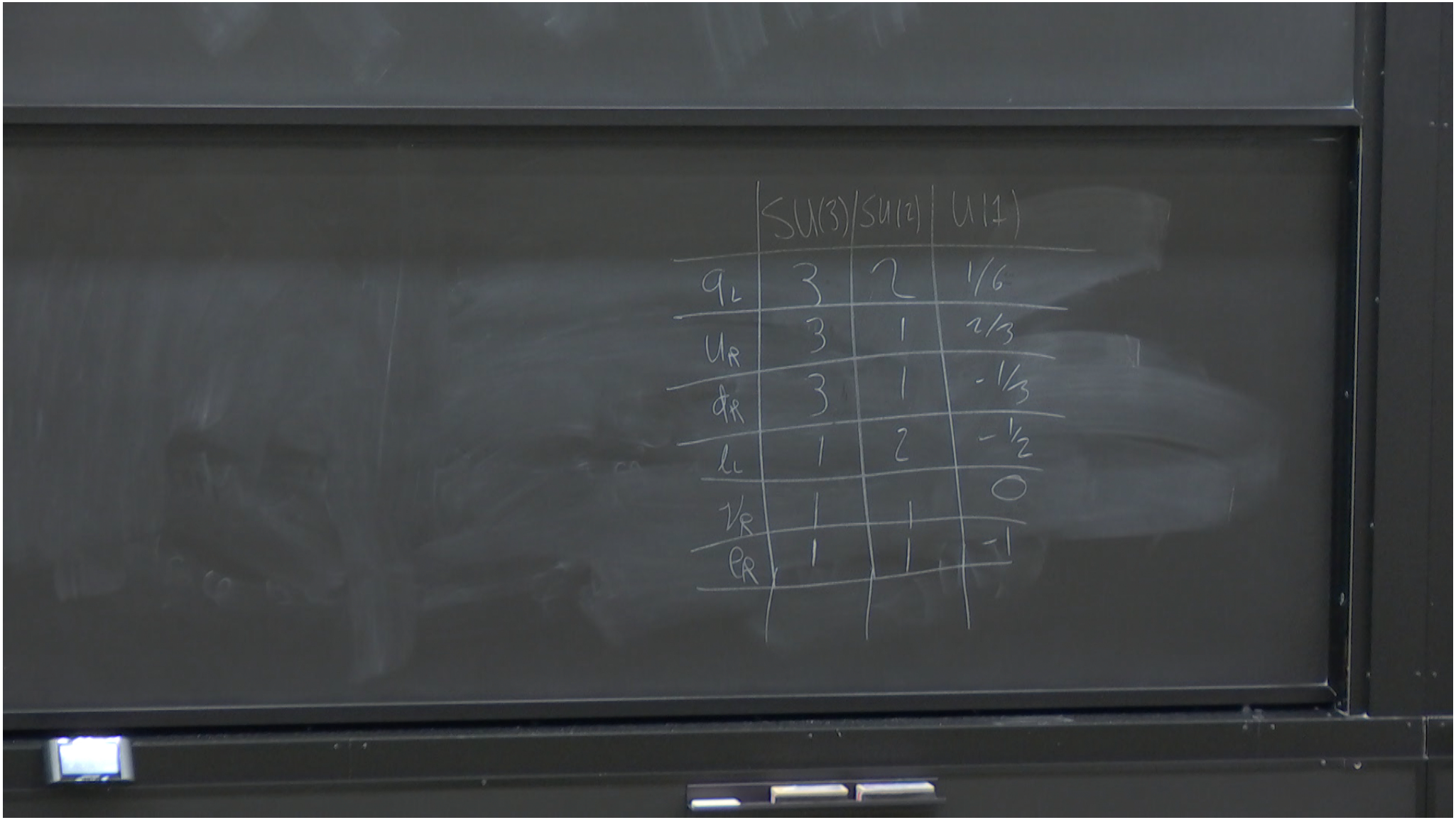
A_μ^c A_ν^b

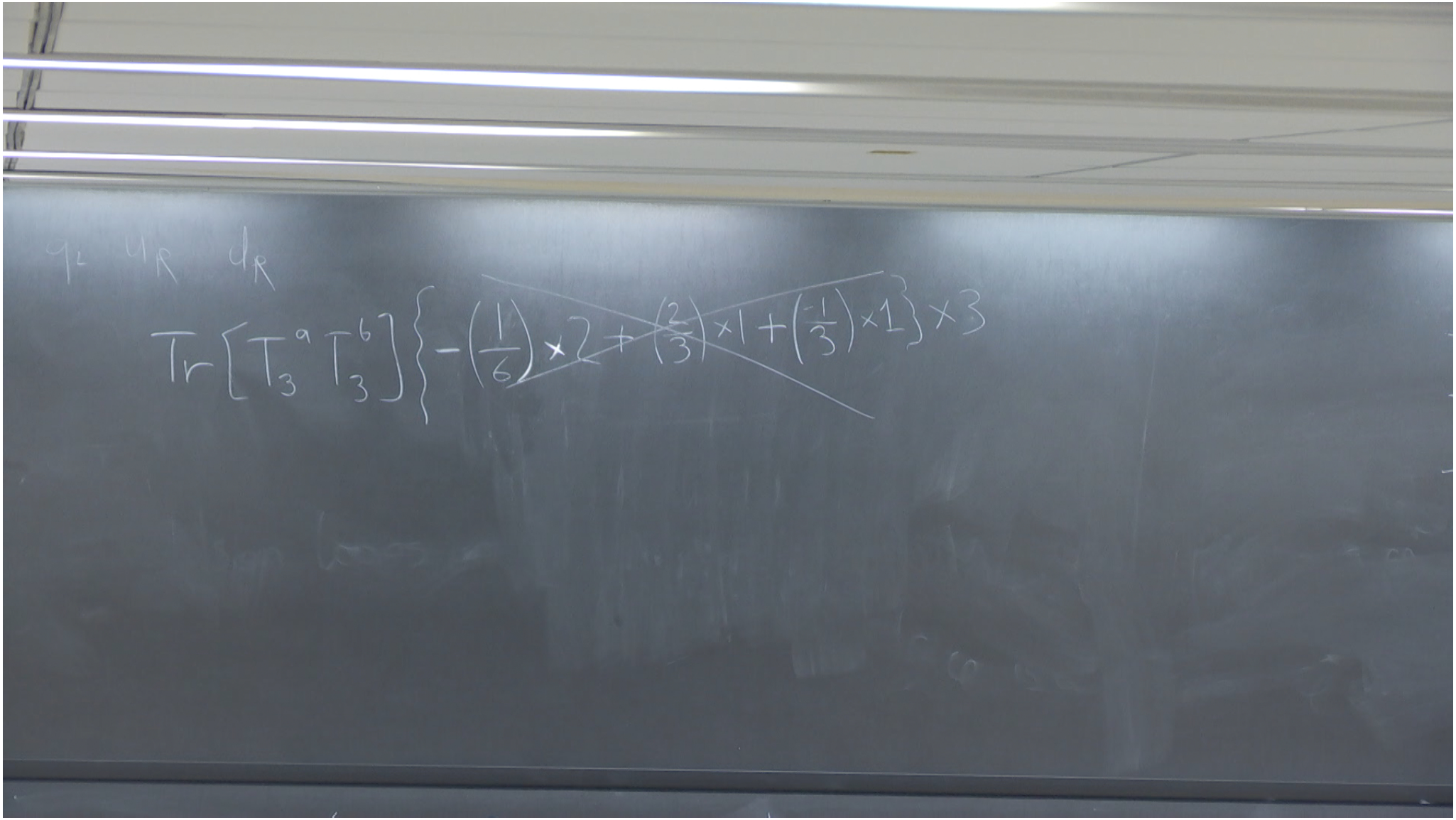
$U(1)_Y\, SU(3)^2$

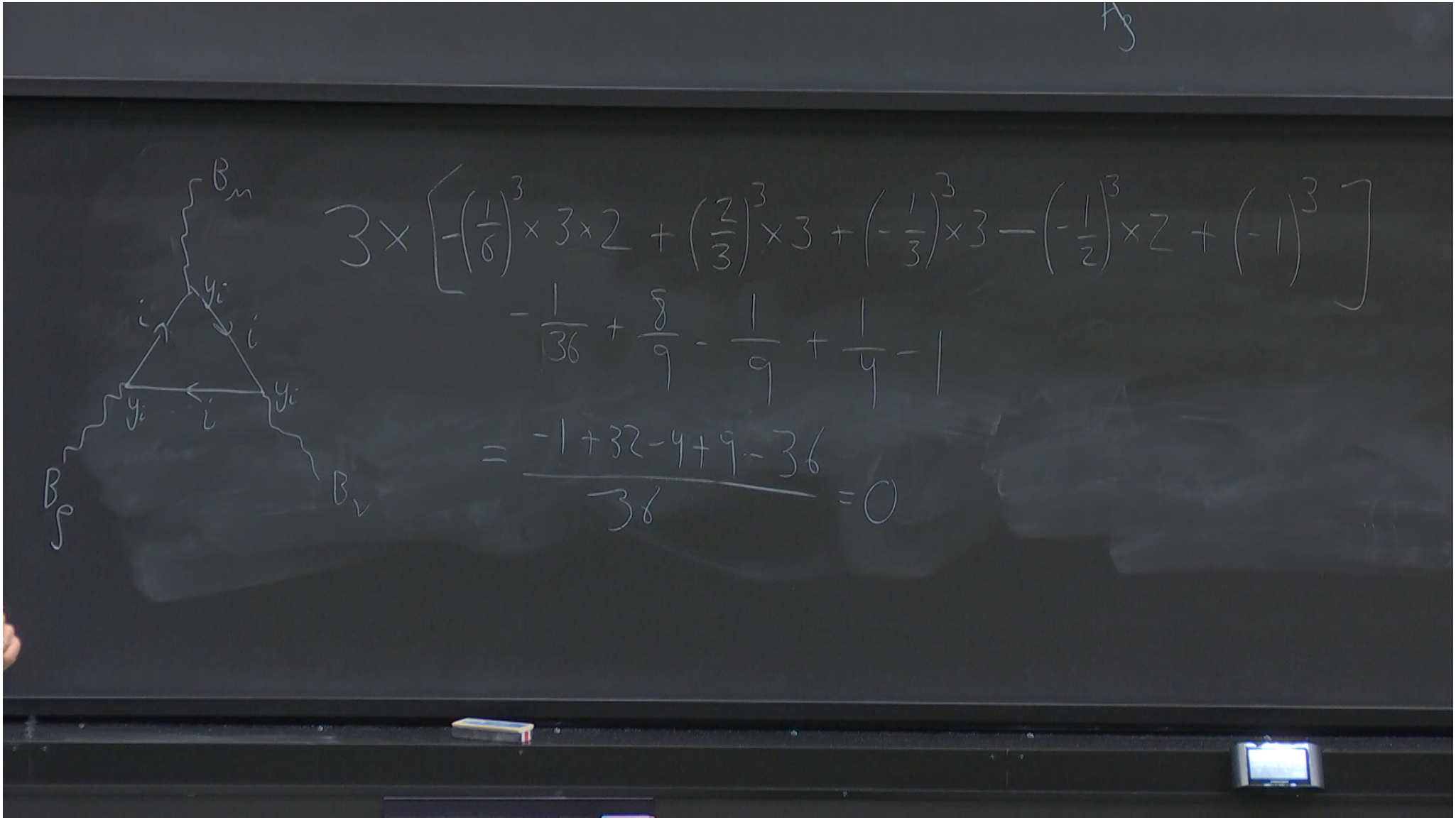
$q_L \quad u_R \quad d_R$

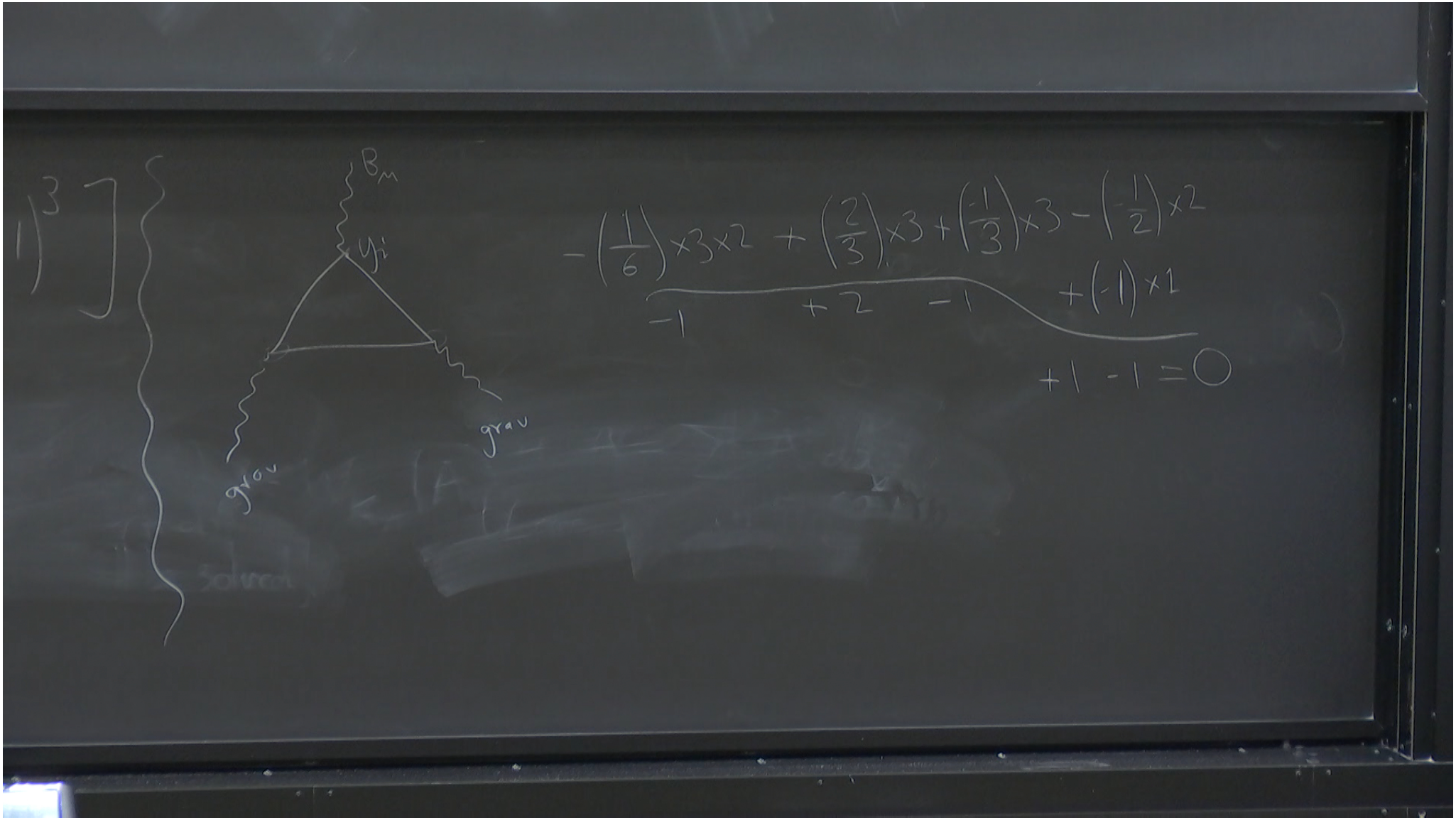


$\mathrm{Tr}\left[T_3^a T_3^b\right] \supset \left(\frac{1}{6}\right)$


SU(3) SU(2) U(1)
q_L 3 2 1/6
u_R 3 1 2/3
d_R 3 1 -1/3
l_L 1 2 -1/2
ν_R 1 1 0
e_R 1 1 -1


$q_L \; u_R \; d_R$
$Tr\left[T_3^a T_3^b\right]\left\{-\left(\frac{1}{6}\right)\times 2+\left(\frac{2}{3}\right)\times 1+\left(\frac{-1}{3}\right)\times 1\right\}\times 3$


B_m
y_i
i
i
y_i
y_i
i
B_p
B_ν
$3\times\left[-\left(\frac{1}{6}\right)^3\times 3\times 2+\left(\frac{2}{3}\right)^3\times 3+\left(-\frac{1}{3}\right)^3\times 3-\left(-\frac{1}{2}\right)^3\times 2+(-1)^3\right]$
$-\frac{1}{36}+\frac{8}{9}-\frac{1}{9}+\frac{1}{4}-1$
$=\frac{-1+32-4+9-36}{36}=0$


B_μ
y_i
grav
grav
$-\left(\frac{1}{6}\right)\times 3\times 2 + \left(\frac{2}{3}\right)\times 3 + \left(\frac{-1}{3}\right)\times 3 - \left(\frac{-1}{2}\right)\times 2$
$+(-1)\times 1$
$-1 \quad +2 \quad -1$
$+1 - 1 = 0$

Ex. 1

	SU(3)	SU(2)	U(1)
q_L	3	2	y_q
u_R	3	1	y_u
d_R	3	1	y_d
l_L	1	2	y_l
$(\nu_R$	1	1	$y_\nu)$
e_R	1	1	y_e
h	1	2	y_h

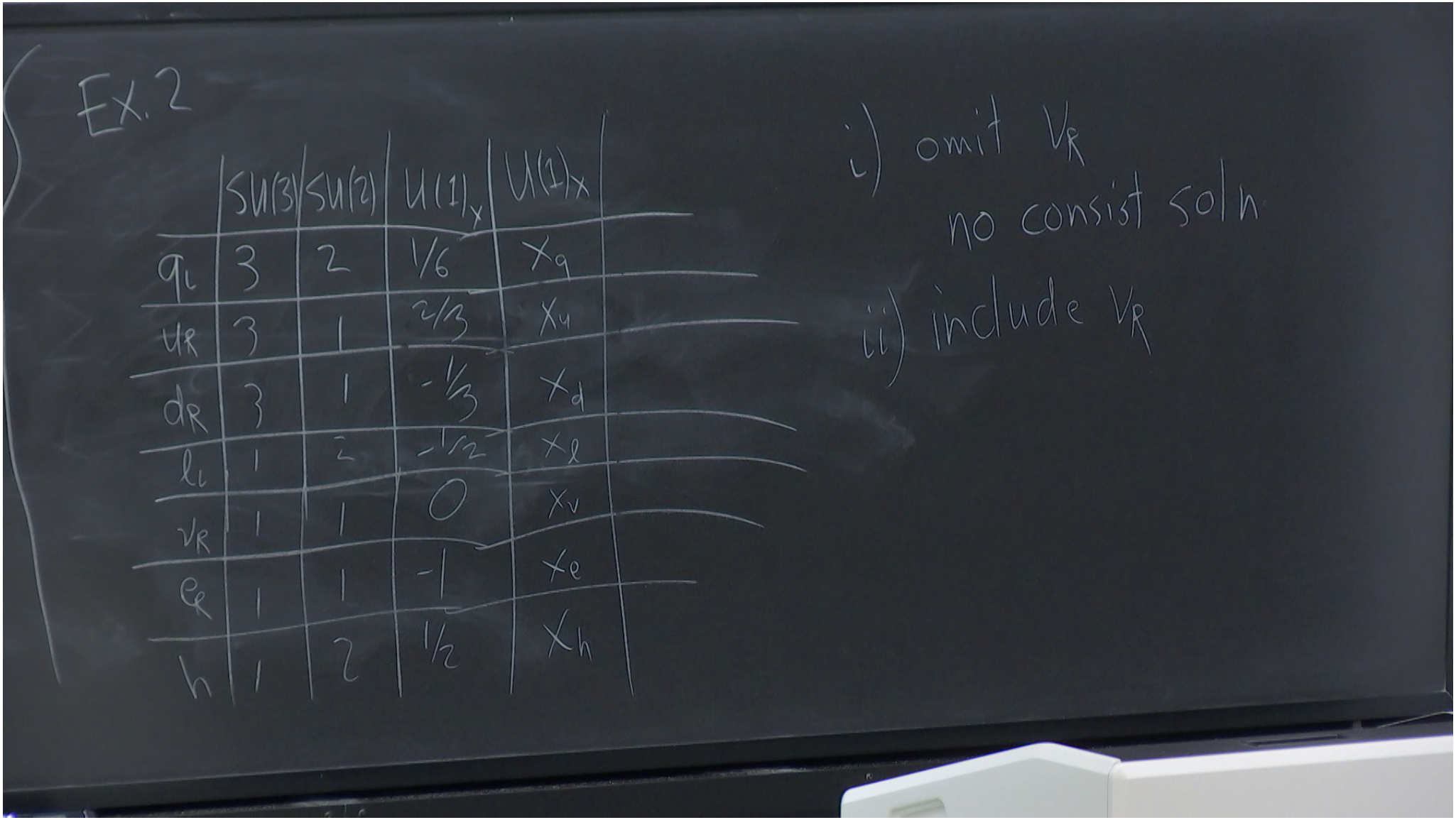
i) anomalies omitting ν_R

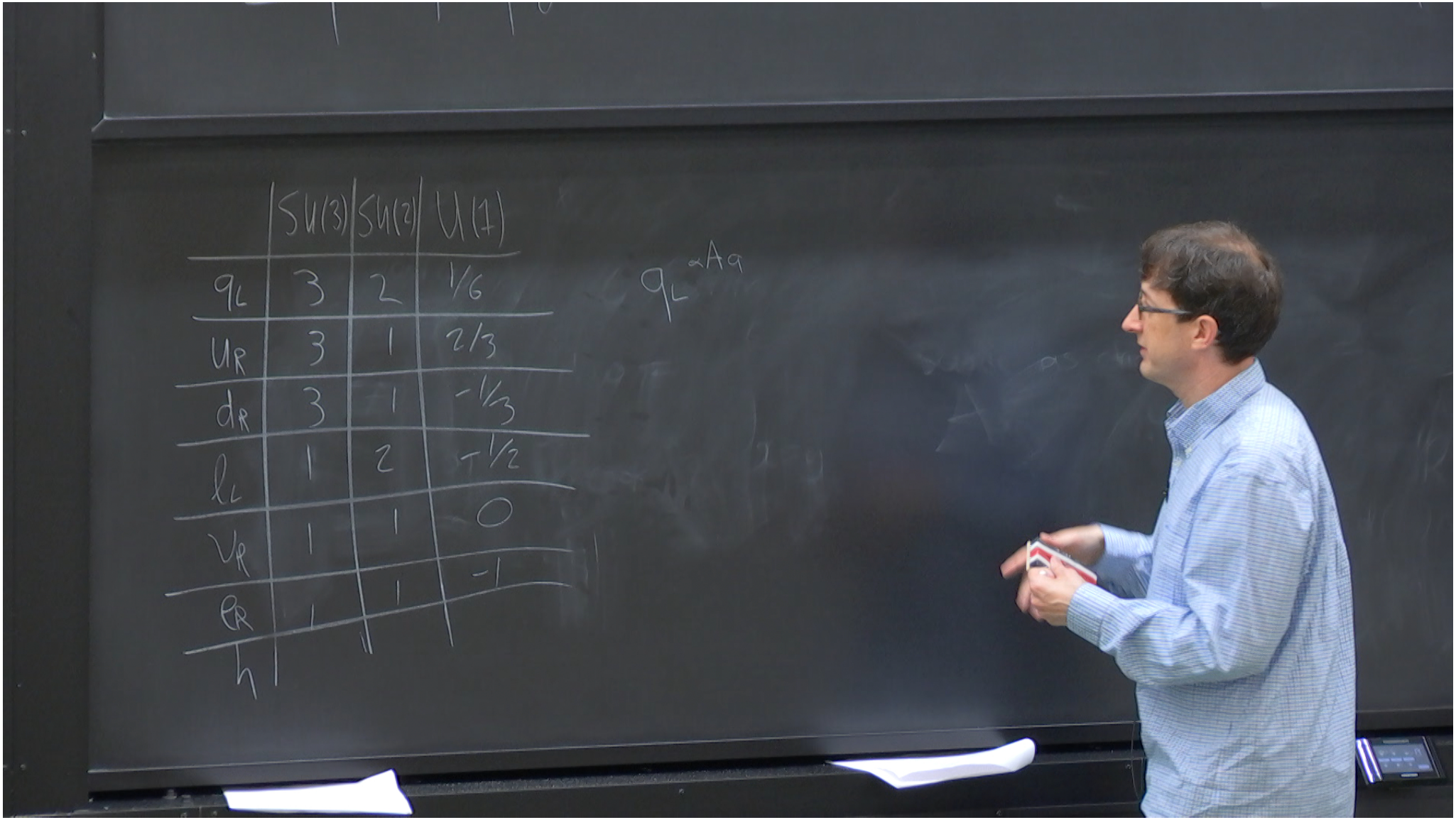
only allowed values are SM values. ~~Y~~

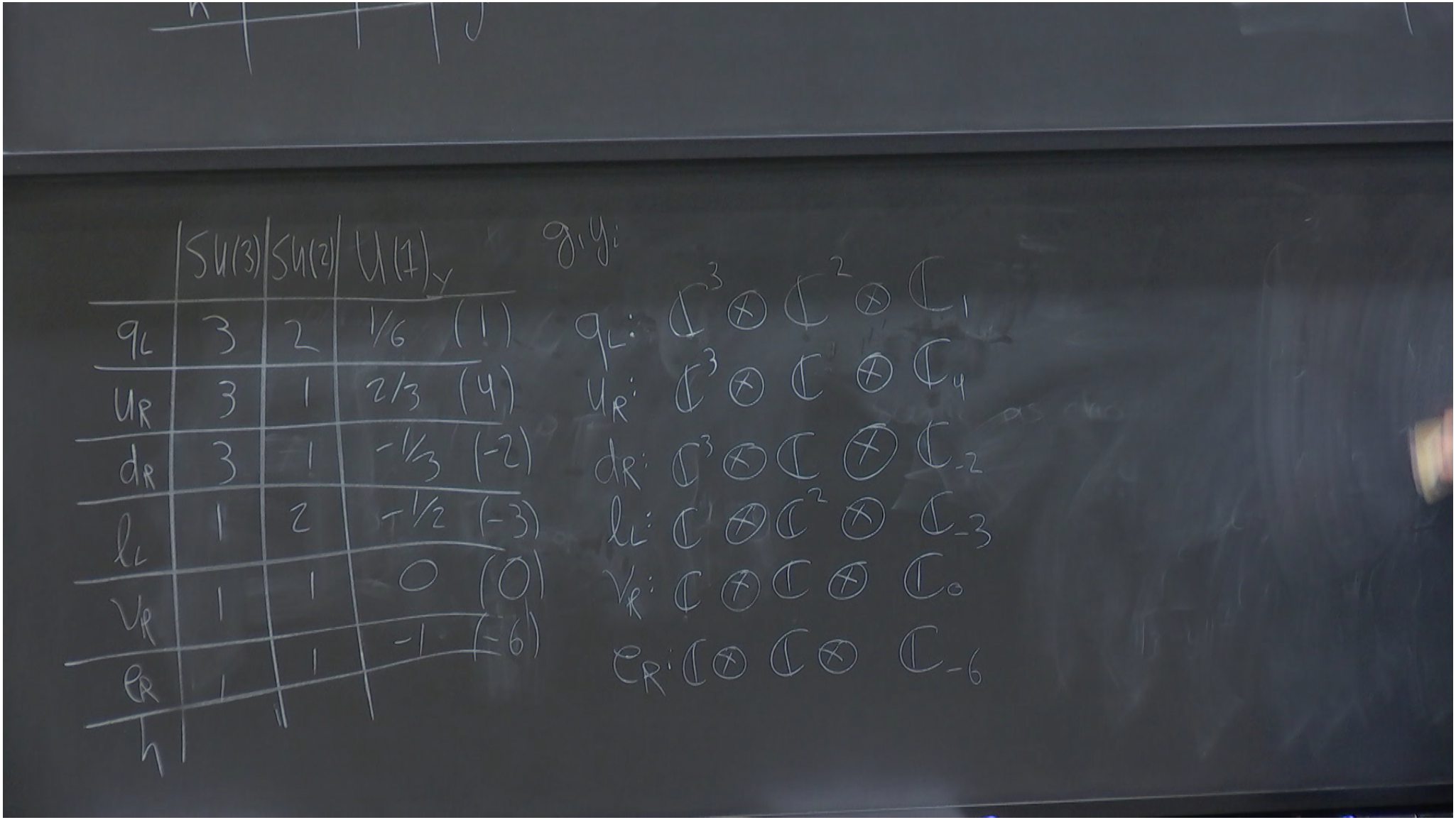
ii) anom. inc. ν_R

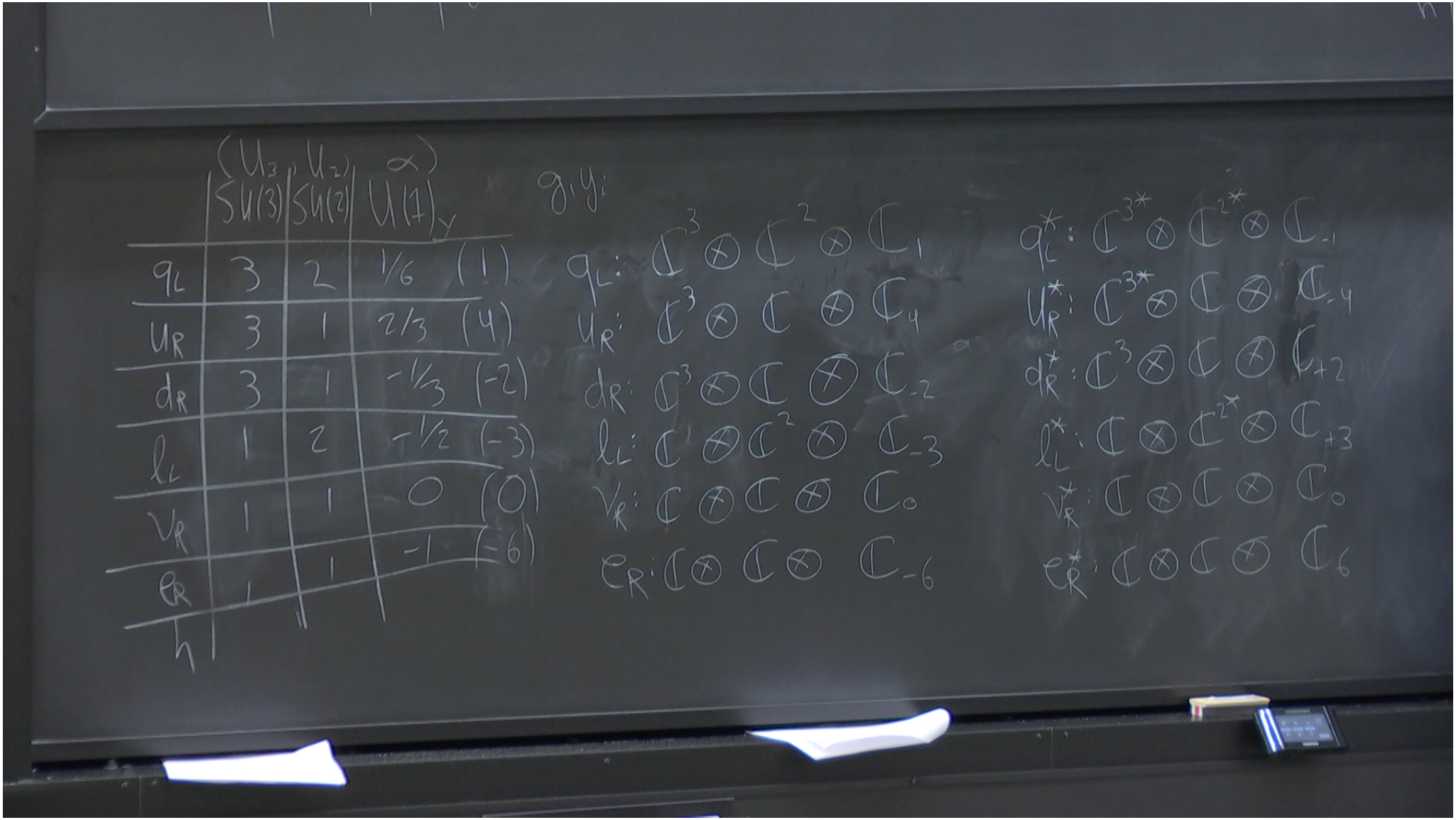
$\propto Y + \beta(B-L)$

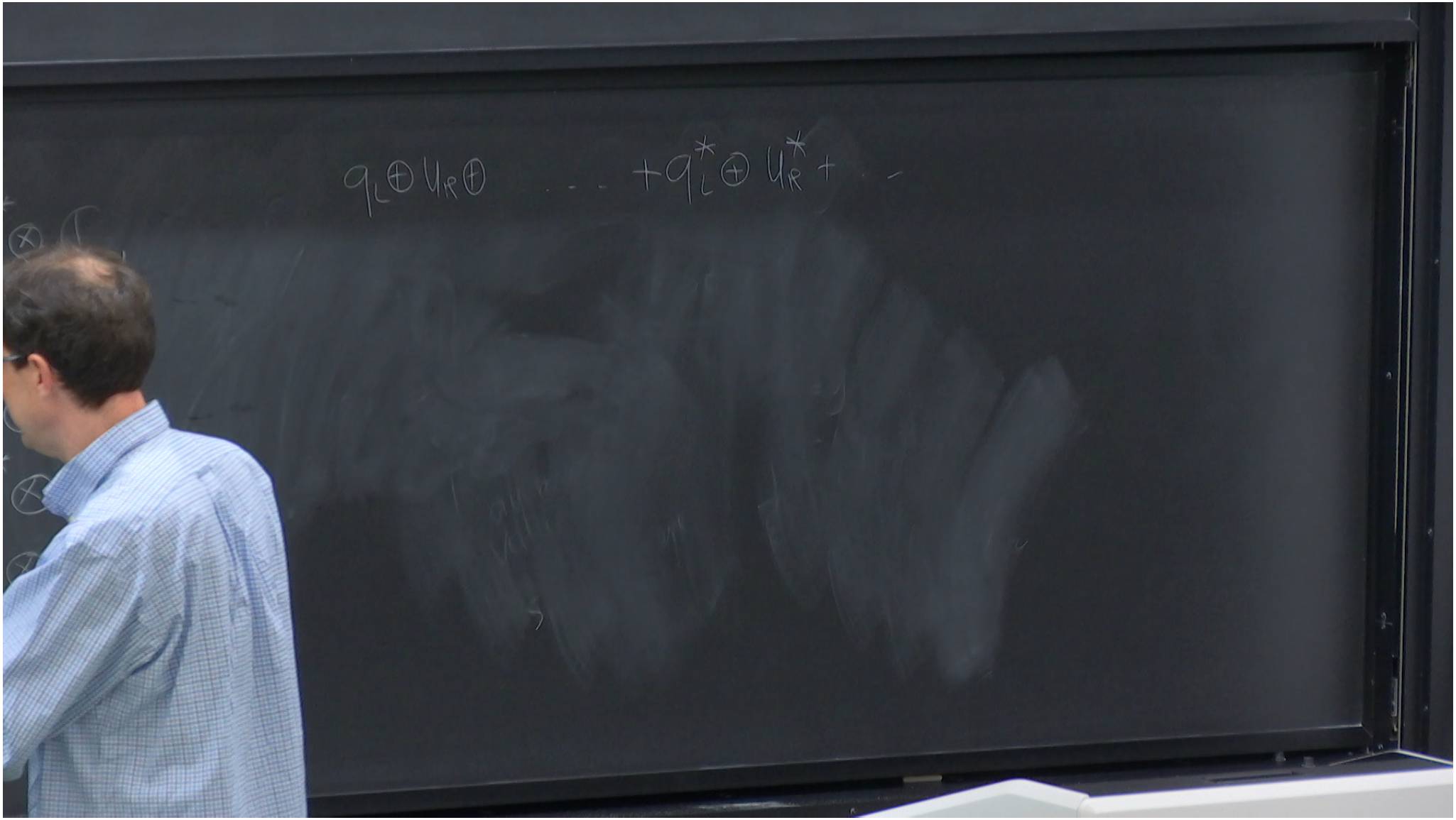
3 7

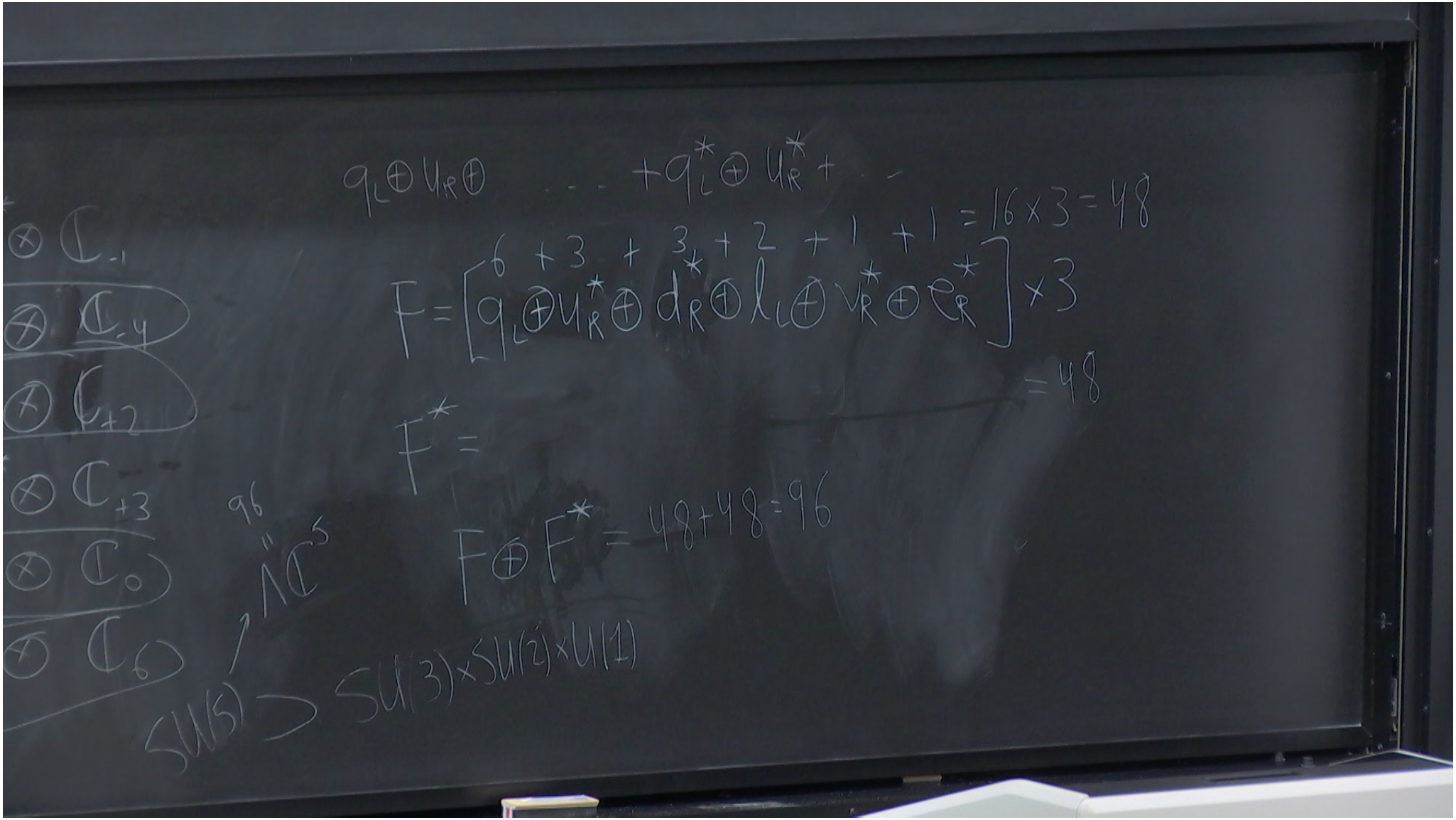

Ex. 2
SU(3) SU(2) U(1)_Y U(1)_X
q_L 3 2 1/6 X_q
u_R 3 1 2/3 X_u
d_R 3 1 -1/3 X_d
l_L 1 2 -1/2 X_l
ν_R 1 1 0 X_ν
e_R 1 1 -1 X_e
h 1 2 1/2 X_h
i) omit ν_R
no consist soln
ii) include ν_R


SU(3) SU(2) U(1)
q_L 3 2 1/6
u_R 3 1 2/3
d_R 3 1 -1/3
l_L 1 2 -1/2
ν_R 1 1 0
e_R 1 1 -1
h
$q_L \sim Aq$


SU(3) SU(2) U(1)_Y
q_L 3 2 1/6 (1)
u_R 3 1 2/3 (4)
d_R 3 1 -1/3 (-2)
l_L 1 2 -1/2 (-3)
ν_R 1 1 0 (0)
e_R 1 1 -1 (-6)
g_i y_i:
q_L: C^3 ⊗ C^2 ⊗ C_1
u_R: C^3 ⊗ C ⊗ C_4
d_R: C^3 ⊗ C ⊗ C_-2
l_L: C ⊗ C^2 ⊗ C_-3
ν_R: C ⊗ C ⊗ C_0
e_R: C ⊗ C ⊗ C_-6


(U_3, U_2, α)
$SU(3)$ $SU(2)$ $U(1)_Y$
q_L 3 2 1/6 (1)
u_R 3 1 2/3 (4)
d_R 3 1 -1/3 (-2)
l_L 1 2 -1/2 (-3)
ν_R 1 1 0 (0)
e_R 1 1 -1 (-6)
h
g.y.
$q_L: \mathbb{C}^3 \otimes \mathbb{C}^2 \otimes \mathbb{C}_1$
$u_R: \mathbb{C}^3 \otimes \mathbb{C} \otimes \mathbb{C}_4$
$d_R: \mathbb{C}^3 \otimes \mathbb{C} \otimes \mathbb{C}_{-2}$
$l_L: \mathbb{C} \otimes \mathbb{C}^2 \otimes \mathbb{C}_{-3}$
$\nu_R: \mathbb{C} \otimes \mathbb{C} \otimes \mathbb{C}_0$
$e_R: \mathbb{C} \otimes \mathbb{C} \otimes \mathbb{C}_{-6}$
$q_L^*: \mathbb{C}^{3*} \otimes \mathbb{C}^{2*} \otimes \mathbb{C}_{-1}$
$u_R^*: \mathbb{C}^{3*} \otimes \mathbb{C} \otimes \mathbb{C}_{-4}$
$d_R^*: \mathbb{C}^3 \otimes \mathbb{C} \otimes \mathbb{C}_{+2}$
$l_L^*: \mathbb{C} \otimes \mathbb{C}^{2*} \otimes \mathbb{C}_{+3}$
$\nu_R^*: \mathbb{C} \otimes \mathbb{C} \otimes \mathbb{C}_0$
$e_R^*: \mathbb{C} \otimes \mathbb{C} \otimes \mathbb{C}_6$


$q_L \otimes u_R \otimes \ldots + q_L^* \otimes u_R^* + \ldots$


$q_L \oplus u_R \oplus \ldots + q_L^* \oplus u_R^* + \ldots$
$6 + 3 + 3^* + 2 + 1 + 1 = 16 \times 3 = 48$
$F = [q_L \oplus u_R^* \oplus d_R \oplus l_L \oplus \nu_R^* \oplus e_R^*] \times 3$
$= 48$
$F^* =$
$F \oplus F^* = 48 + 48 = 96$
$\mathbb{C}_{-1}$
$\mathbb{C}_{-4}$
$\mathbb{C}_{+2}$
$\mathbb{C}_{+3}$
$\mathbb{C}_0$
$\mathbb{C}_6$
96
$\Lambda \mathbb{C}^5$
$SU(5) \supset SU(3) \times SU(2) \times U(1)$