Title: PSI 2018/2019 - Beyond Standard Model - Lecture 3

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Collection: PSI 2018/2019 - Beyond Standard Model (Boyle)

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URL: http://pirsa.org/19030065

1) Pick a $G = SU(3) \times SU(2) \times U(1)$. 3)

2)

	$SU(3)_c$	$SU(2)_L$	$U(1)_Y$
q_L	3	2	1/6
u_R	3	1	2/3
d_R	3	1	-1/3
l_L	1	2	-1/2
e_R	1	1	-1
h	1	2	1/2

$q_L = \begin{pmatrix} u_L \\ d_L \end{pmatrix}$

$l_L = \begin{pmatrix} \nu_L \\ e_L \end{pmatrix}$

$\times SU(2) \times U(1)$.

3) . mass dim ≤ 4
· Lorentz inv
· $SU(3) \times SU(2) \times U(1)$ inv.

$U(1)_Y$

1/6 $q_L = \begin{pmatrix} u_L \\ d_L \end{pmatrix}$

2/3

-1/3

-1/2 $l_L = \begin{pmatrix} \nu_L \\ e_L \end{pmatrix}$

-1

1/2

1) Pick a $G = SU(3) \times SU(2) \times U(1)$.

2)

	G_μ $SU(3)_c$	W_μ $SU(2)_L$	B_μ $U(1)_Y$
q_L	3	2	1/6
u_R	3	1	2/3
d_R	3	1	-1/3
l_L	1	2	-1/2
[illegible]			
e_R	1	1	-1
h	1	2	1/2

$q_L = \begin{pmatrix} u_L \\ d_L \end{pmatrix}$

$l_L = \begin{pmatrix} \nu_L \\ e_L \end{pmatrix}$

3) · mass dim ≤ 4

· Lorentz inv

· $SU(3) \times SU(2)$

4) $D_\mu = \partial_\mu + igA_\mu$

$D_\mu = \partial_\mu + ig_3 G_\mu + ig_2 W_\mu + ig_1 B_\mu$

$U_3 \quad U_2 \quad U_1$

$U(1)$ inv.

$A_\mu \to U A_\mu U^{-1} + \frac{i}{g}(\partial_\mu U) U^{-1}$

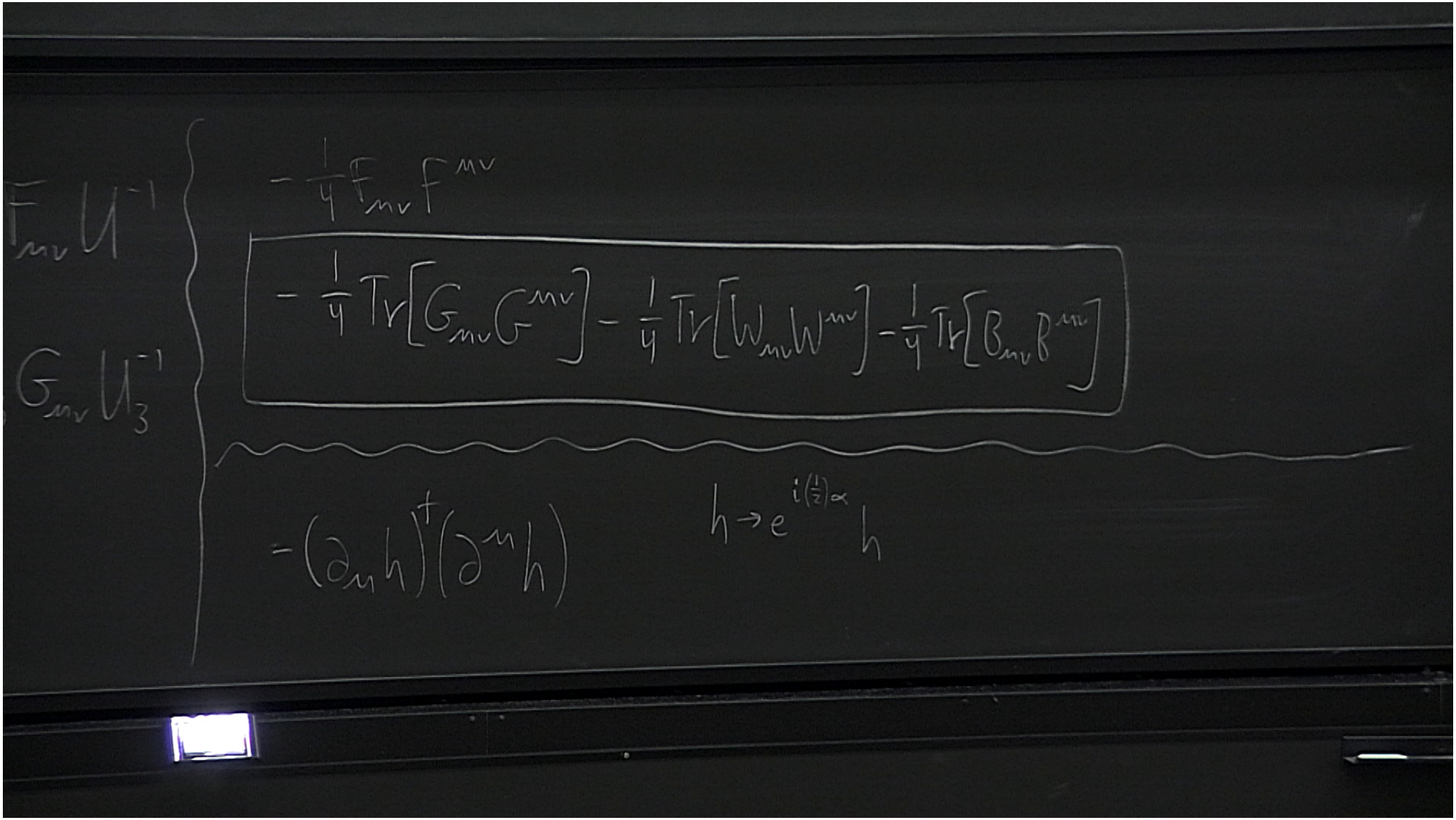
$G_\mu \to U_3 G_\mu U_3^{-1} + \frac{i}{g_3}(\partial_\mu U_3) U_3^{-1}$

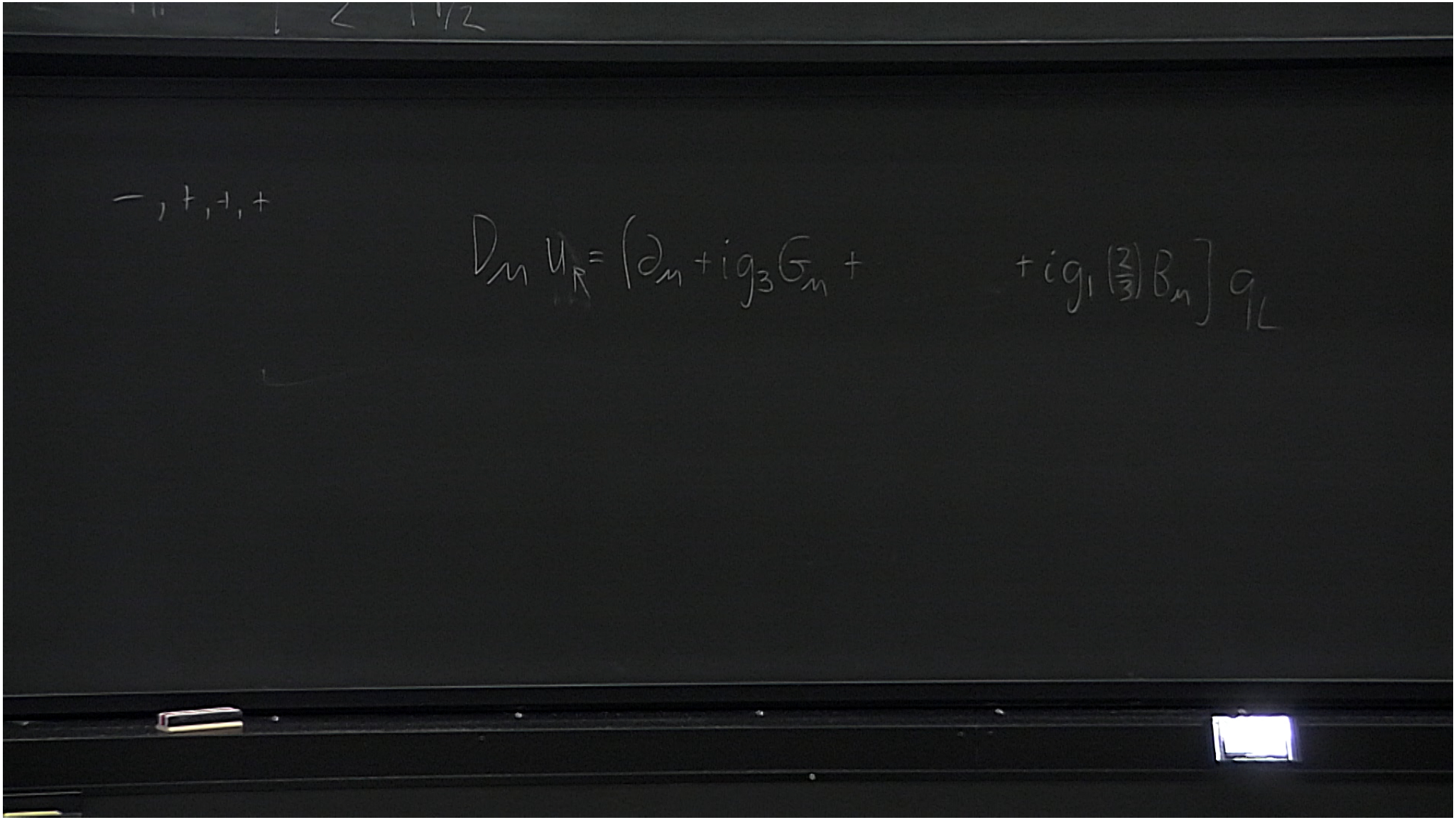
$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu + ig[A_\mu, A_\nu] \Longrightarrow F_{\mu\nu} \to U F_{\mu\nu} U^{-1}$$

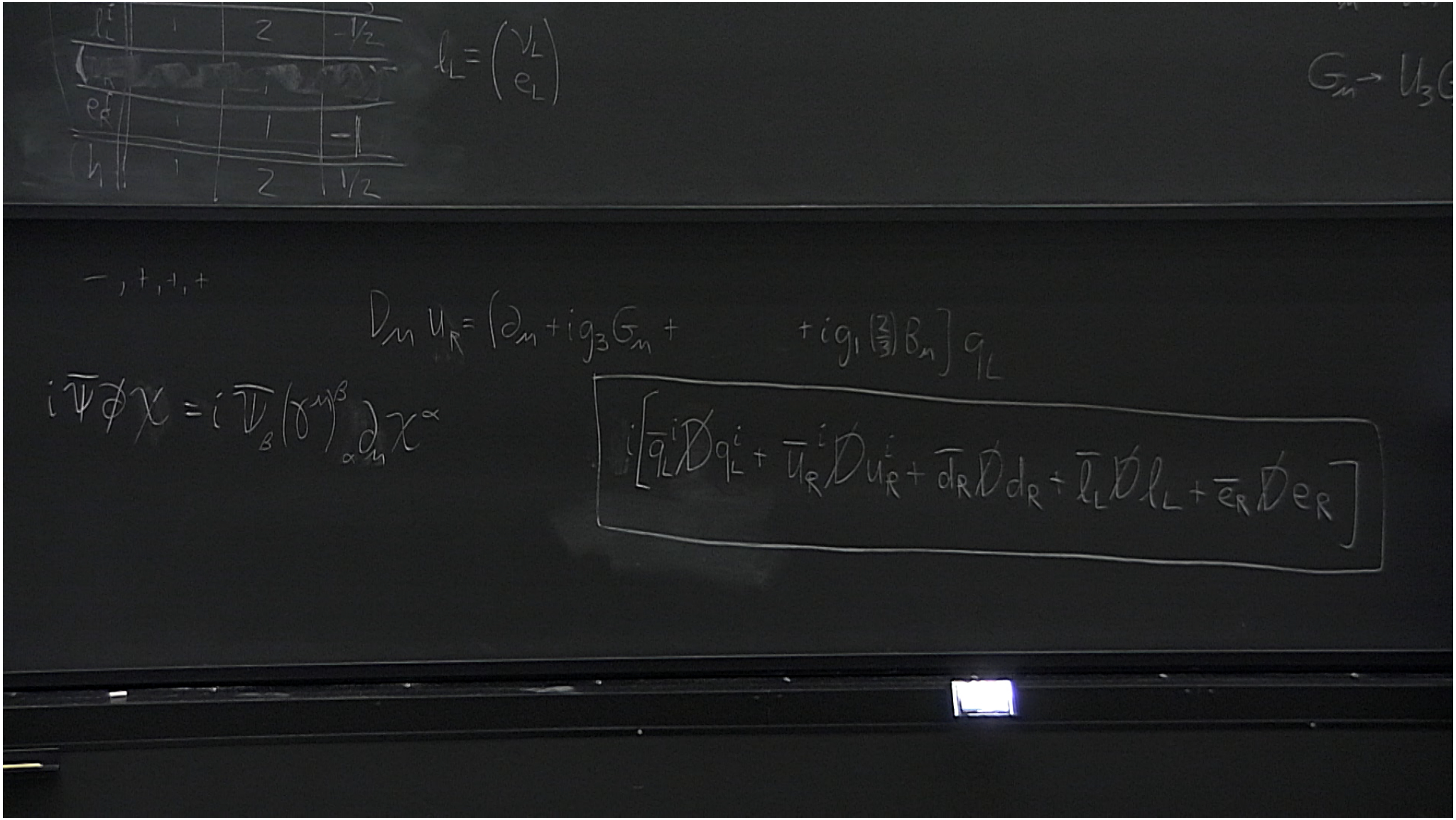
$$G_{\mu\nu} = \partial_\mu G_\nu - \partial_\nu G_\mu + ig_3[G_\mu, G_\nu] \Longrightarrow G_{\mu\nu} \to U_3 G_{\mu\nu} U_3^{-1}$$

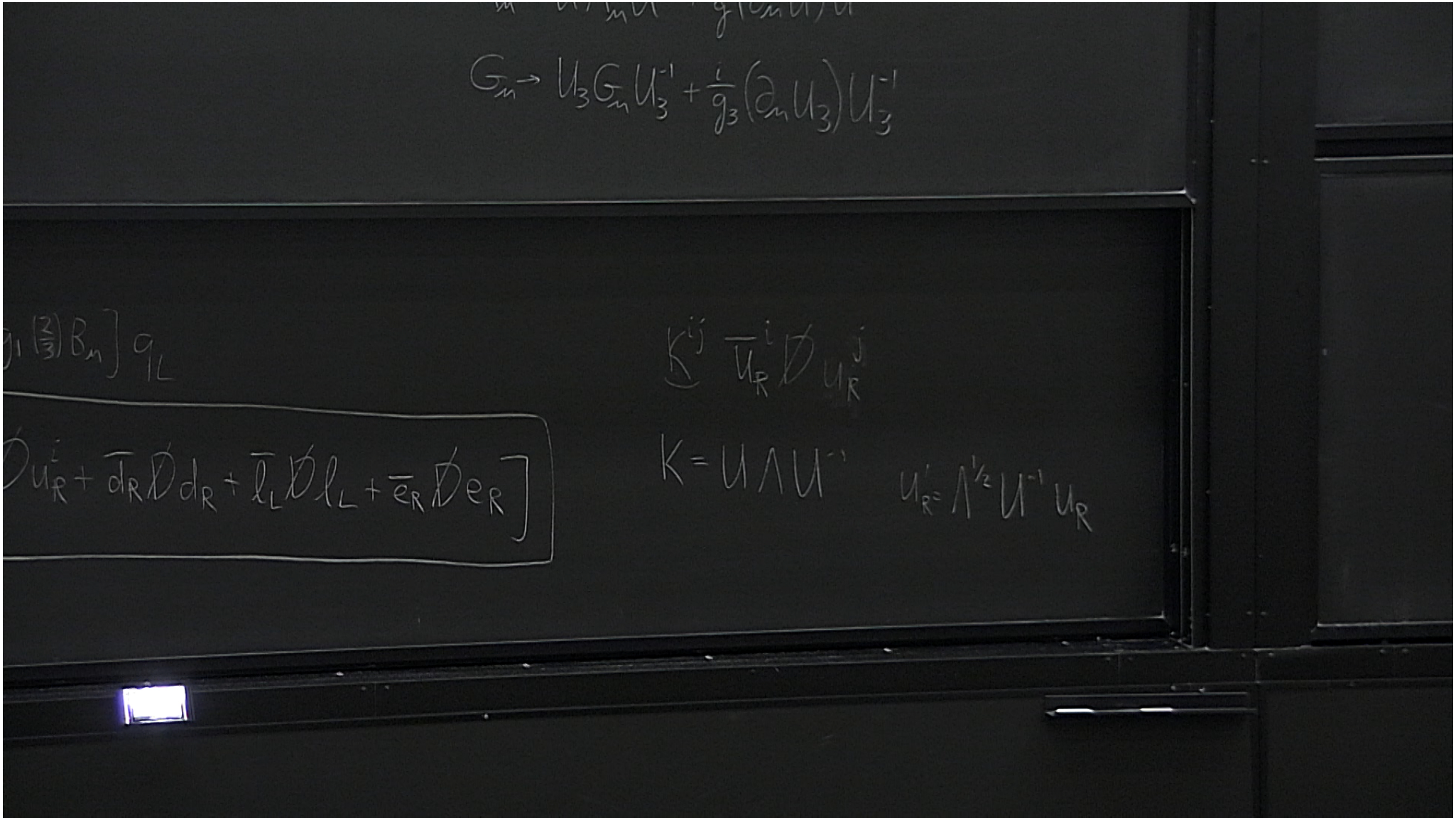
$$W_{\mu\nu} = \ldots$$

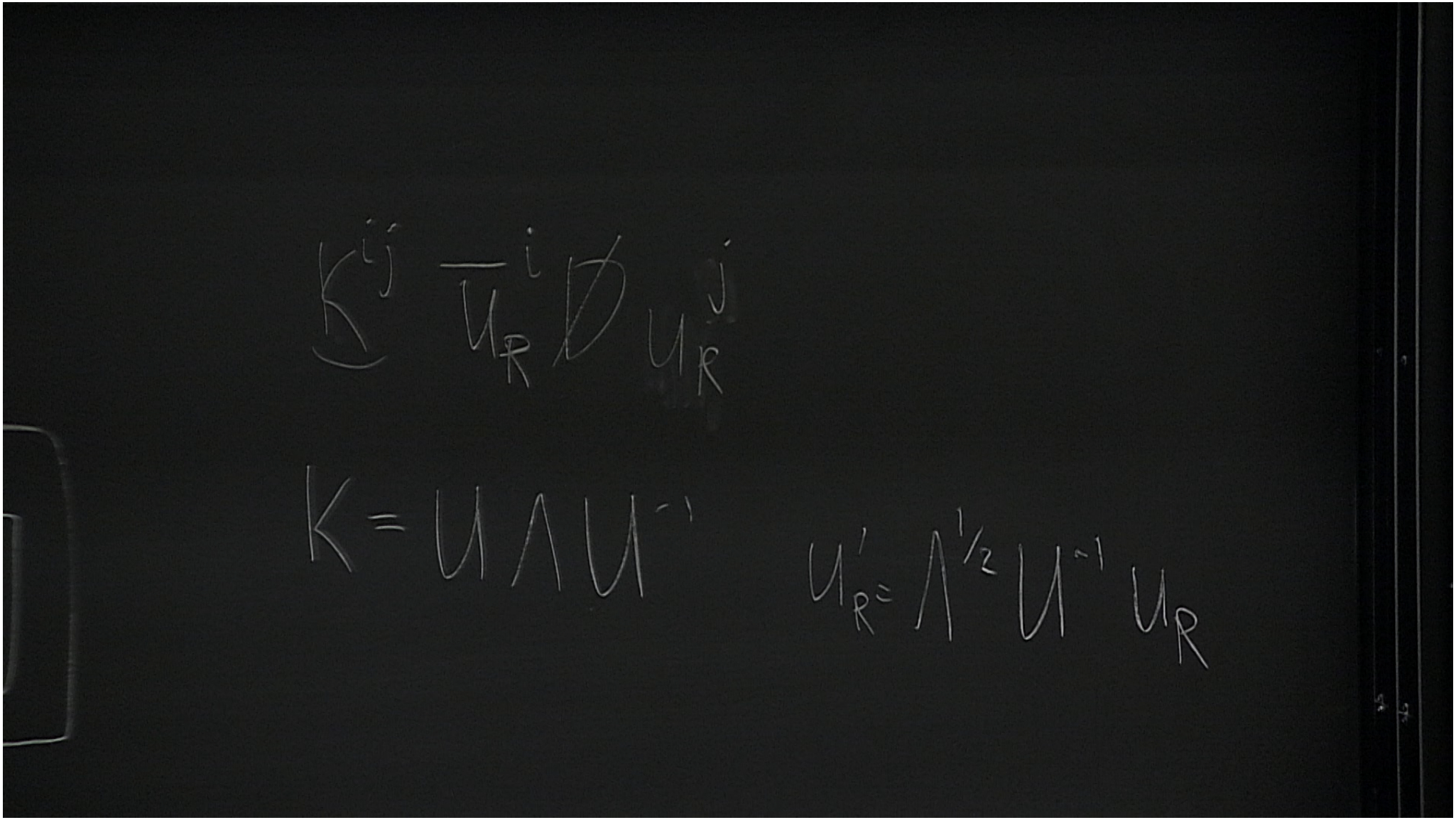
$$B_{\mu\nu} = \ldots$$

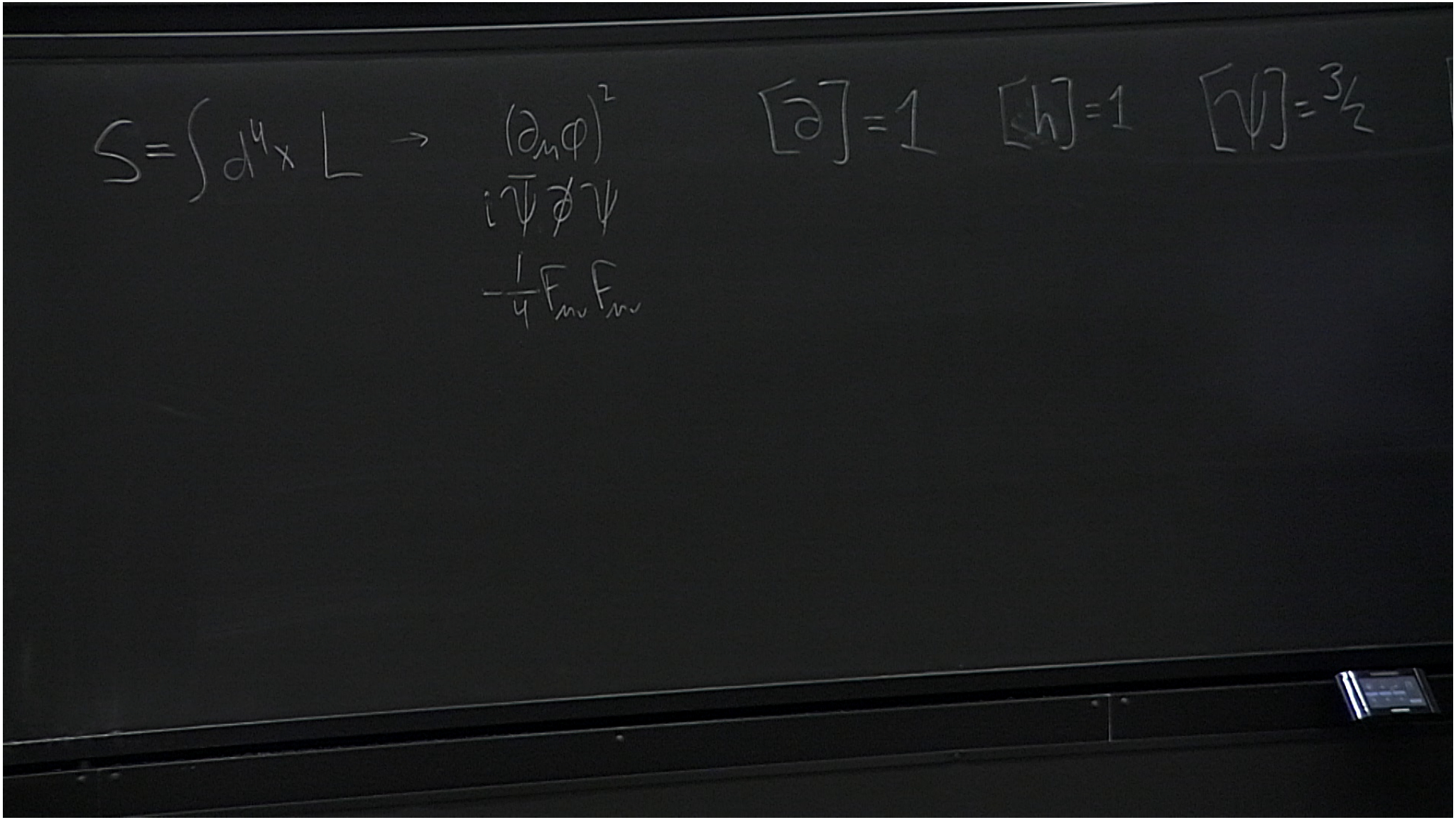

$F_{\mu\nu} U^{-1}$
$G_{\mu\nu} U_3^{-1}$
$-\frac{1}{4} f_{\mu\nu} f^{\mu\nu}$
$-\frac{1}{4} \mathrm{Tr}[G_{\mu\nu} G^{\mu\nu}] - \frac{1}{4} \mathrm{Tr}[W_{\mu\nu} W^{\mu\nu}] - \frac{1}{4} \mathrm{Tr}[B_{\mu\nu} B^{\mu\nu}]$
$-(\partial_\mu h)^\dagger (\partial^\mu h)$
$h \to e^{i(\frac{1}{2})\alpha} h$

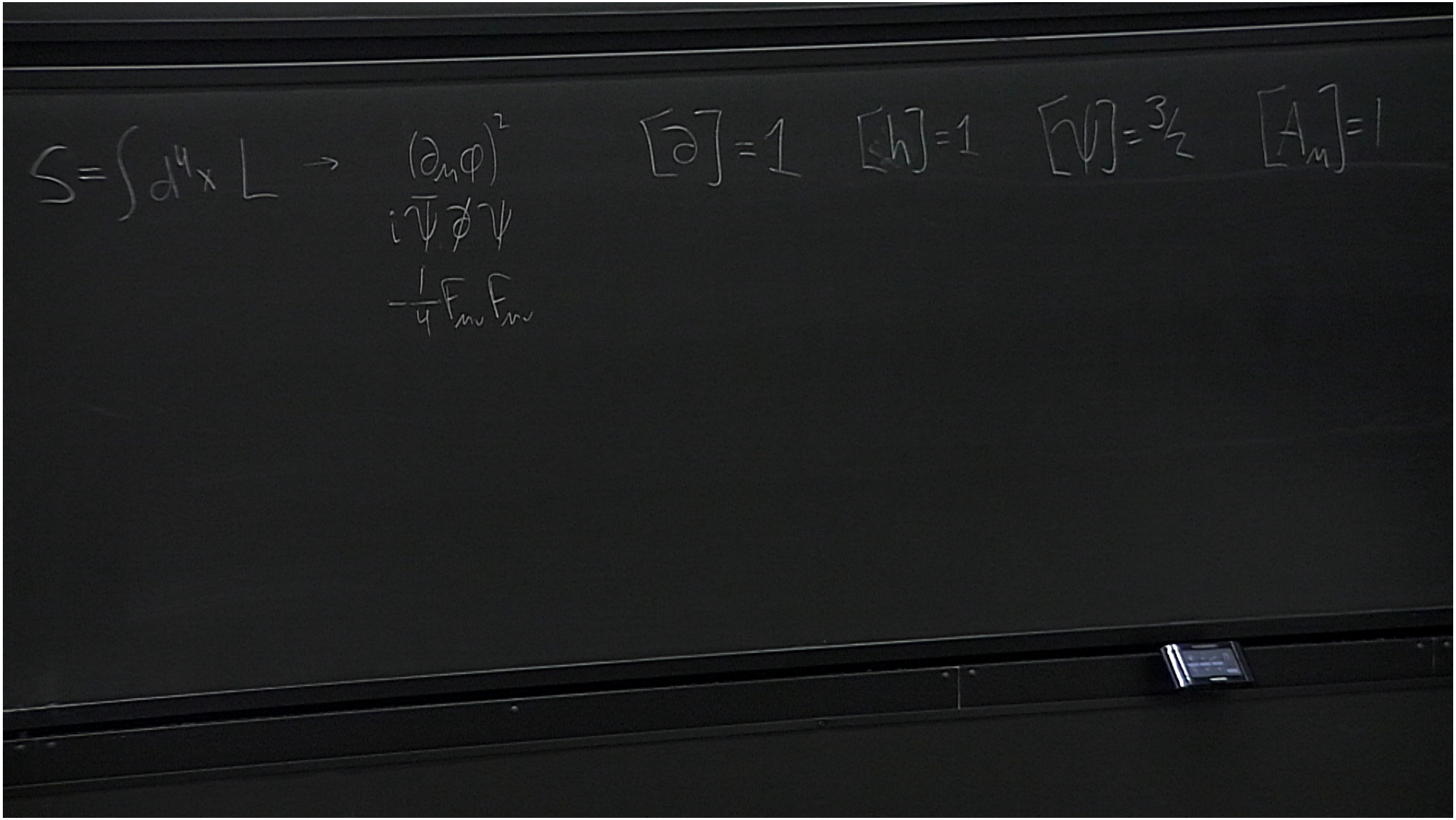

$-, +, +, +$
$D_\mu u_R = (\partial_\mu + i g_3 G_\mu + \quad + i g_1 (\frac{2}{3}) B_\mu] q_L$


l_L^i 1 2 $-1/2$
e_R^i 1 1 -1
u_R^i 1 2 $1/2$
$l_L = \begin{pmatrix} \nu_L \\ e_L \end{pmatrix}$
$G_\mu \to U_3 G$
$-, +, +, +$
$D_\mu u_R = (\partial_\mu + i g_3 G_\mu + \quad + i g_1 (\frac{2}{3}) B_\mu) q_L$
$i \bar{\psi} \not{\partial} \chi = i \bar{\psi}_\beta (\gamma^\mu)^\beta_\alpha \partial_\mu \chi^\alpha$
$i [\bar{q}_L^i \not{D} q_L^i + \bar{u}_R^i \not{D} u_R^i + \bar{d}_R \not{D} d_R + \bar{l}_L \not{D} l_L + \bar{e}_R \not{D} e_R]$

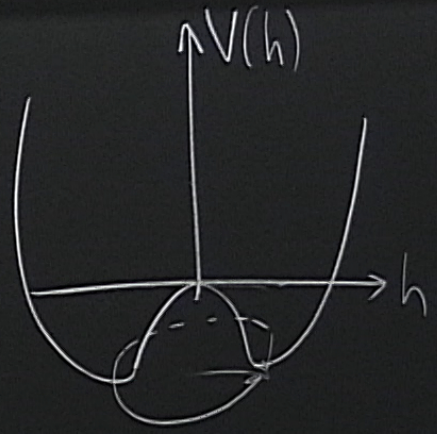

$G_m \to U_3 G_m U_3^{-1} + \frac{i}{g_3}(\partial_m U_3) U_3^{-1}$
$\left(\frac{2}{3}\right) B_m \Big] q_L$
$K^{ij}\ \bar{u}_R^i \not{D} u_R^j$
$\not{D} u_R^i + \bar{d}_R \not{D} d_R + \bar{l}_L \not{D} l_L + \bar{e}_R \not{D} e_R \Big]$
$K = U \Lambda U^{-1}$
$u_R' = \Lambda^{1/2} U^{-1} u_R$

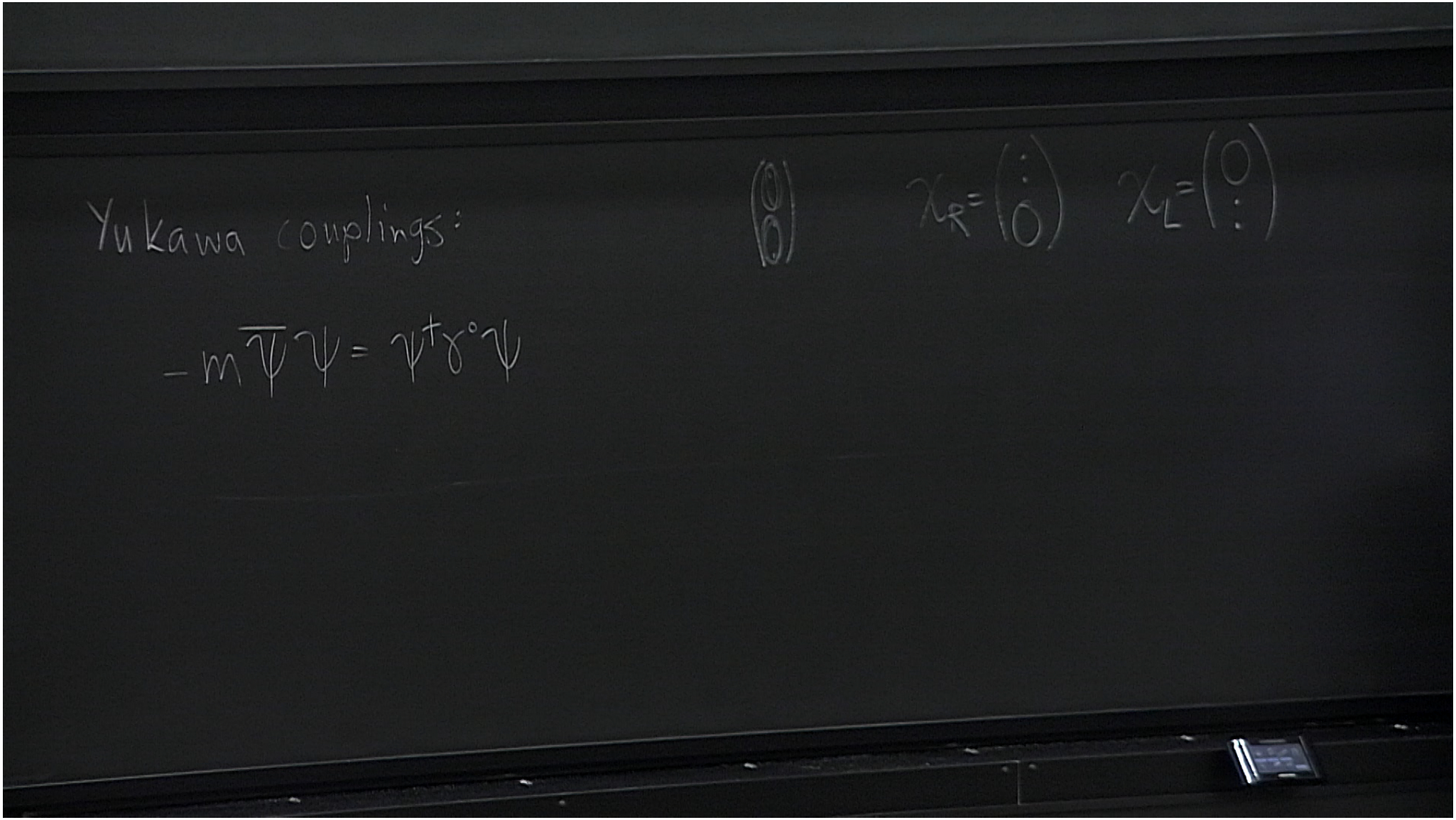

$K^{ij}\ \overline{U_R^i}\not{D}U_R^j$
$K = U\Lambda U^{-1}$
$U'_R = \Lambda^{1/2} U^{-1} U_R$

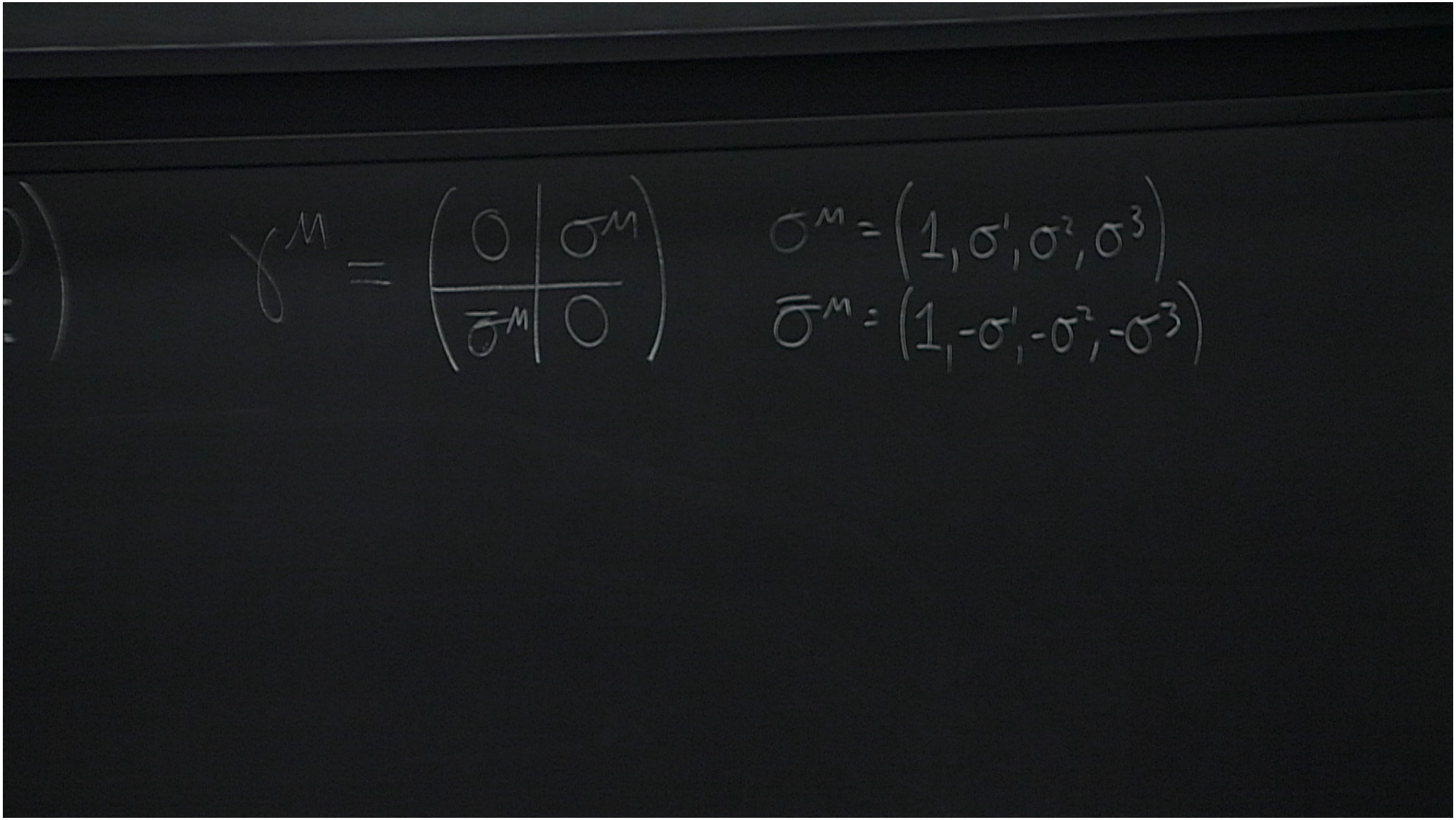

$S = \int d^4x\, L \rightarrow$
$(\partial_\mu \varphi)^2$
$i\bar{\psi}\partial\!\!\!/\psi$
$-\frac{1}{4} F_{\mu\nu} F_{\mu\nu}$
$[\partial] = 1$
$[h] = 1$
$[\psi] = 3/2$


$S = \int d^4x\, L \rightarrow$
$(\partial_\mu \varphi)^2$
$i\bar{\psi} \not{\partial} \psi$
$-\frac{1}{4} F_{\mu\nu} F_{\mu\nu}$
$[\partial] = 1$
$[h] = 1$
$[\psi] = 3/2$
$[A_\mu] = 1$

$$+m^2(h^\dagger h) - \frac{\lambda}{4}(h^\dagger h)^2 = -V(h)$$




Yukawa couplings:
$-m\bar{\psi}\psi = \psi^\dagger\gamma^0\psi$
$\begin{pmatrix}0\\0\end{pmatrix}$
$\chi_R = \begin{pmatrix}\cdot\\0\end{pmatrix}$
$\chi_L = \begin{pmatrix}0\\\cdot\end{pmatrix}$


$\gamma^\mu = \begin{pmatrix} 0 & \sigma^\mu \\ \bar{\sigma}^\mu & 0 \end{pmatrix}$
$\sigma^\mu = (1, \sigma^1, \sigma^2, \sigma^3)$
$\bar{\sigma}^\mu = (1, -\sigma^1, -\sigma^2, -\sigma^3)$

Yukawa couplings: $\psi = \begin{pmatrix} \psi_R \\ \psi_L \end{pmatrix}$ $\begin{pmatrix} 0 \\ 0 \end{pmatrix}$ $\chi_R = \begin{pmatrix} \cdot \\ 0 \end{pmatrix}$ $\chi_L = \begin{pmatrix} 0 \\ \cdot \end{pmatrix}$

$$\bar{\psi}\psi = \psi^\dagger \gamma^0 \psi = \bar{\psi}_L \psi_R + \bar{\psi}_R \psi_L$$

Yukawa couplings: $\psi = \begin{pmatrix} \psi_R \\ \psi_L \end{pmatrix}$ $\begin{pmatrix} 0 \\ 0 \end{pmatrix}$ $\chi_R = \begin{pmatrix} \cdot \\ 0 \end{pmatrix}$ $\chi_L = \begin{pmatrix} 0 \\ \cdot \end{pmatrix}$

$\bar{\psi}\psi = \psi^\dagger \gamma^0 \psi = \bar{\psi}_L \psi_R + \bar{\psi}_R \psi_L$ $\quad \tilde{h} = -i\sigma^2 h^*$

$$-\left[\bar{q}_L^i Y_d^{ij} h\, d_R^j + \bar{q}_L^i Y_u^{ij} \tilde{h}\, u_R + \bar{l}_L^i Y_e^{ij} h\, e_R\right] + \text{h.c.}$$