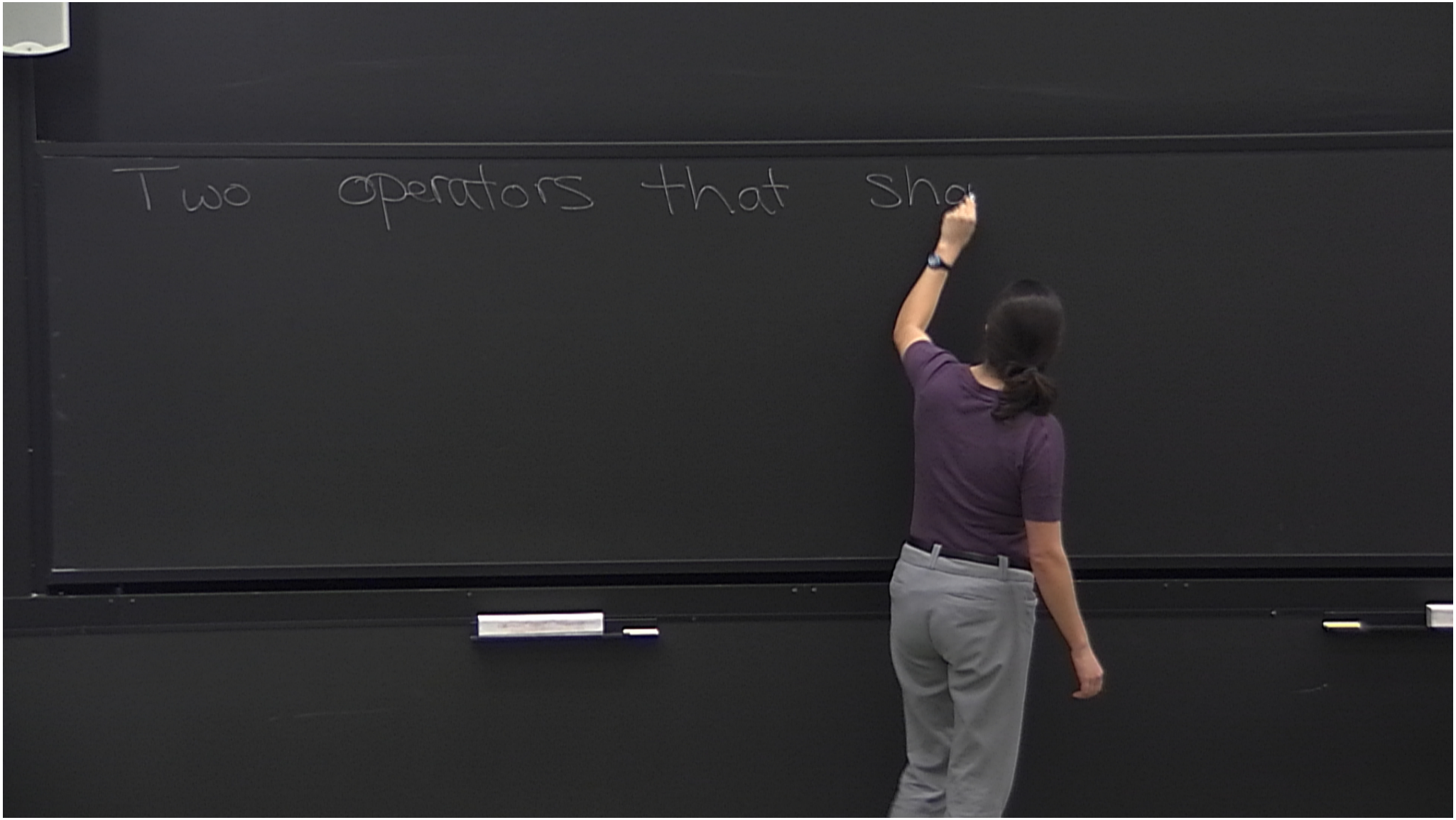
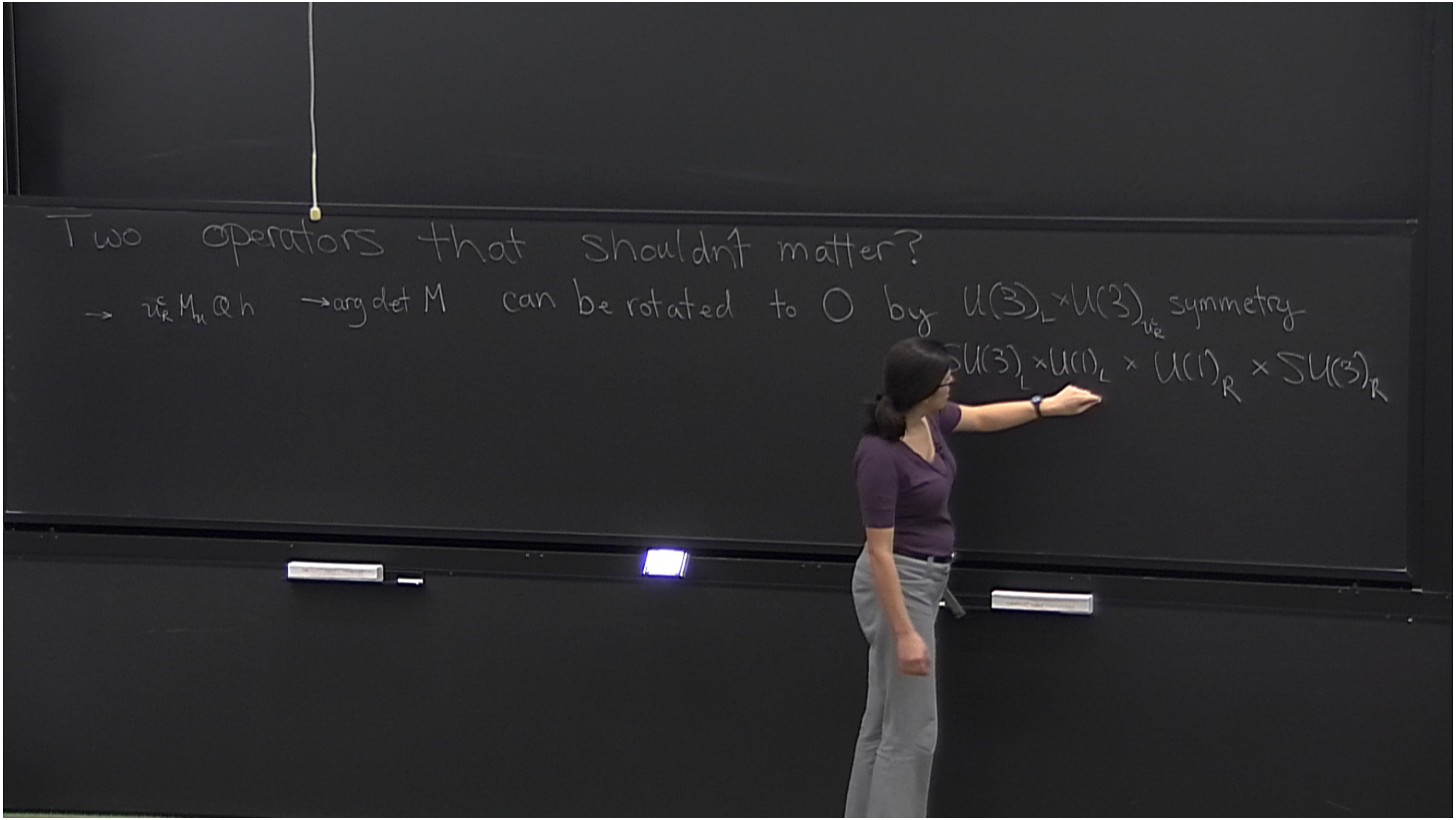
Title: 12/13 PSI - Beyond the Standard Model Lecture 13

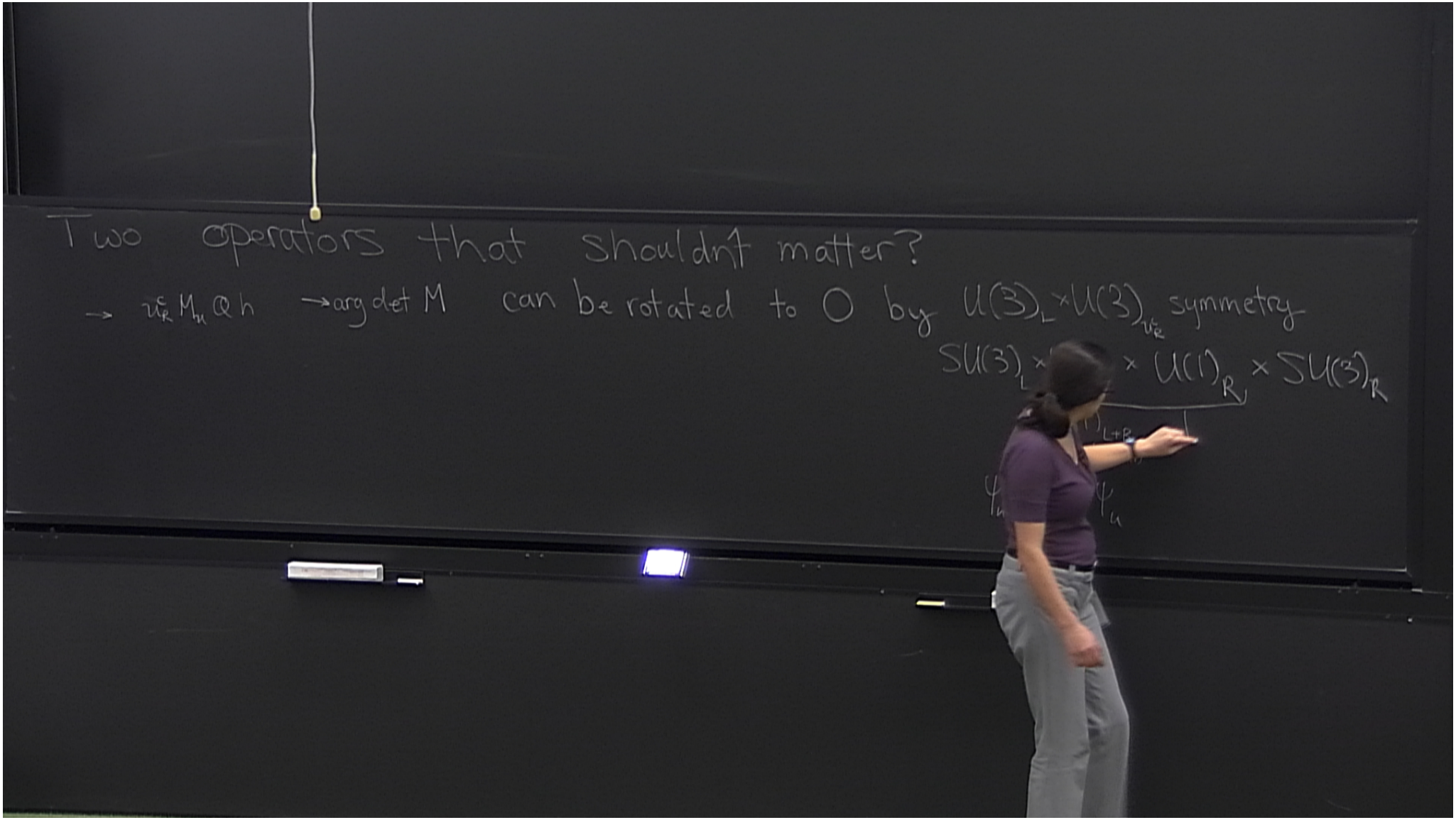
Date: Mar 07, 2013 09:00 AM

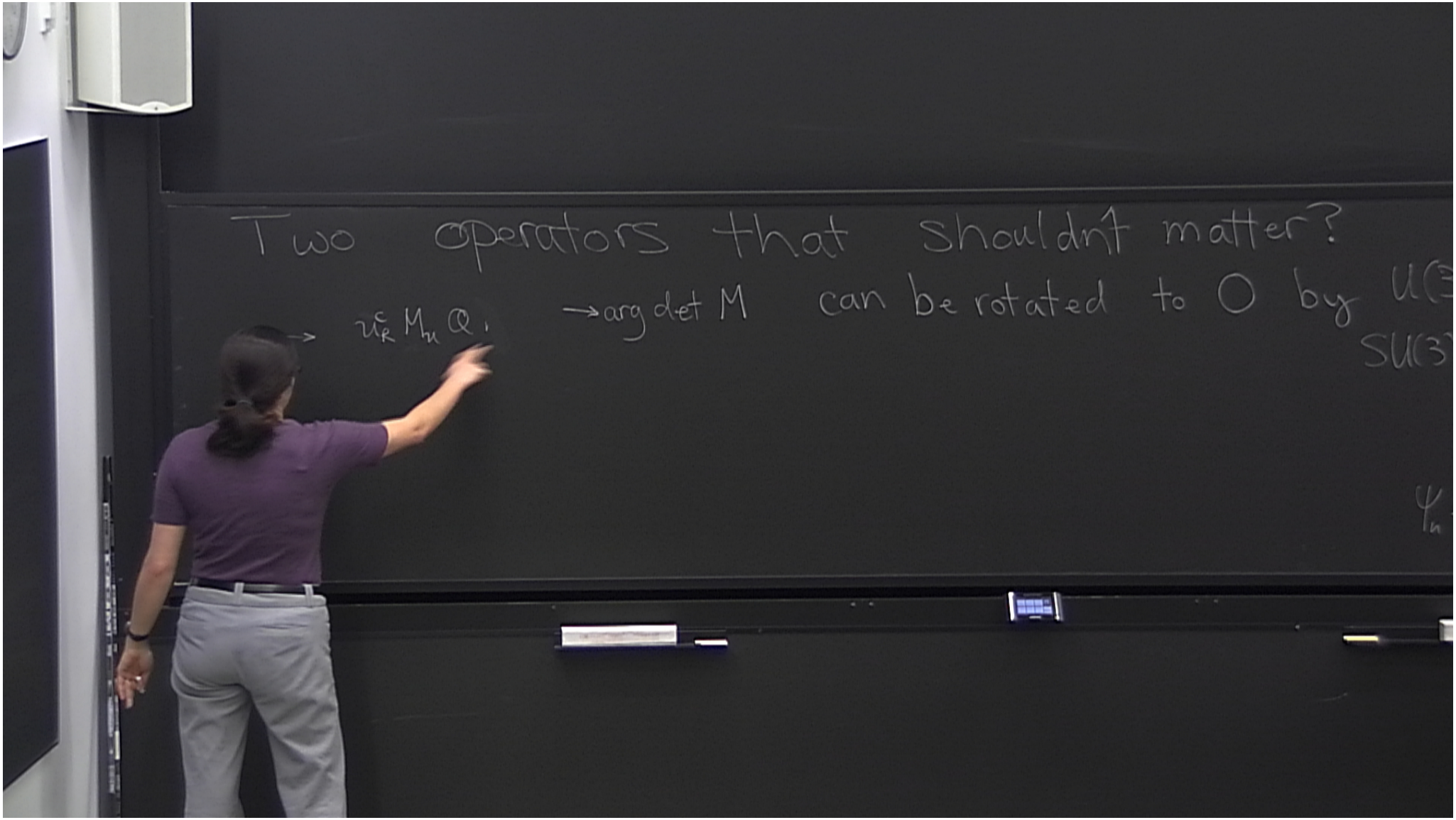
URL: http://pirsa.org/13030036

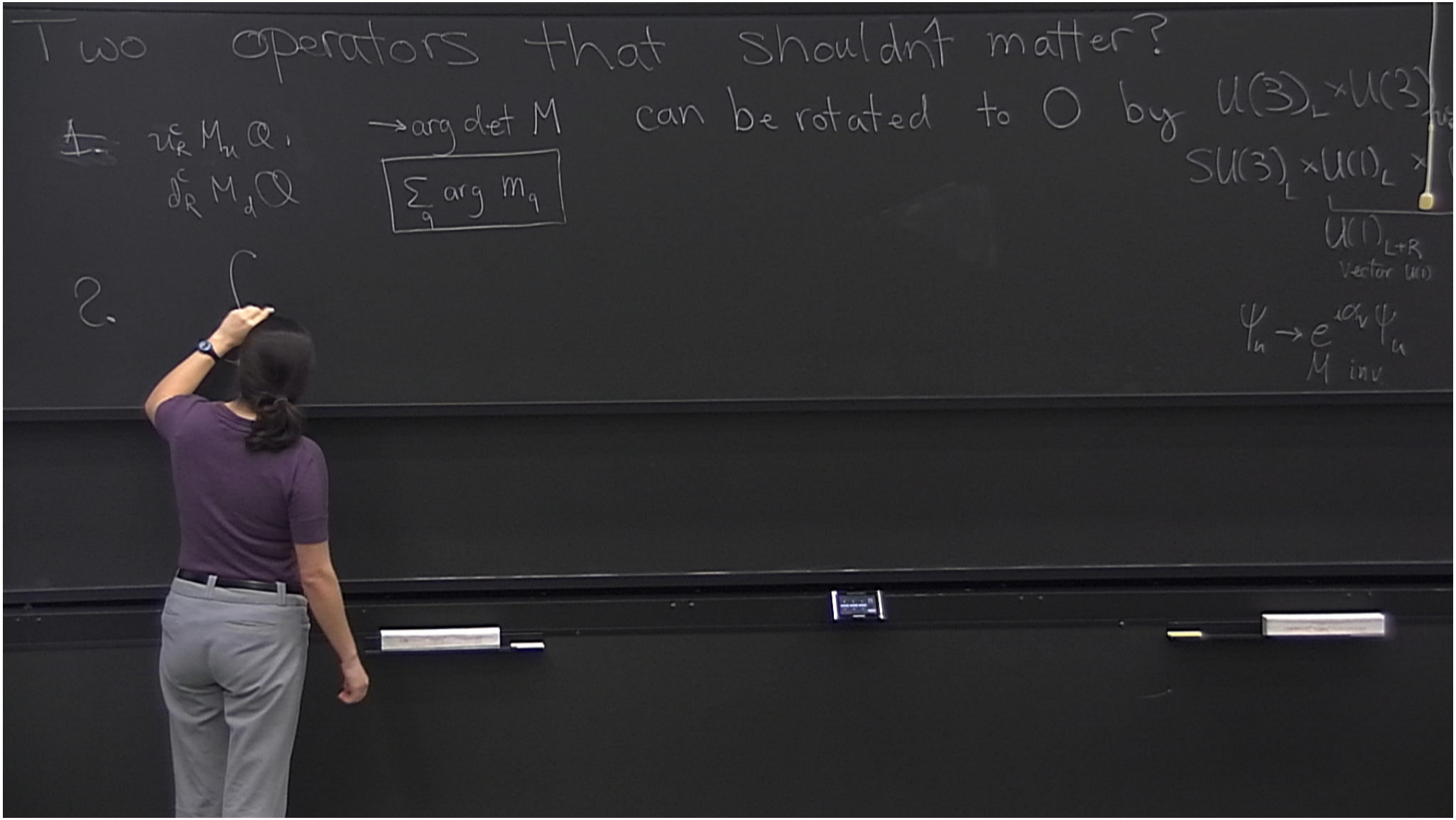
Abstract:

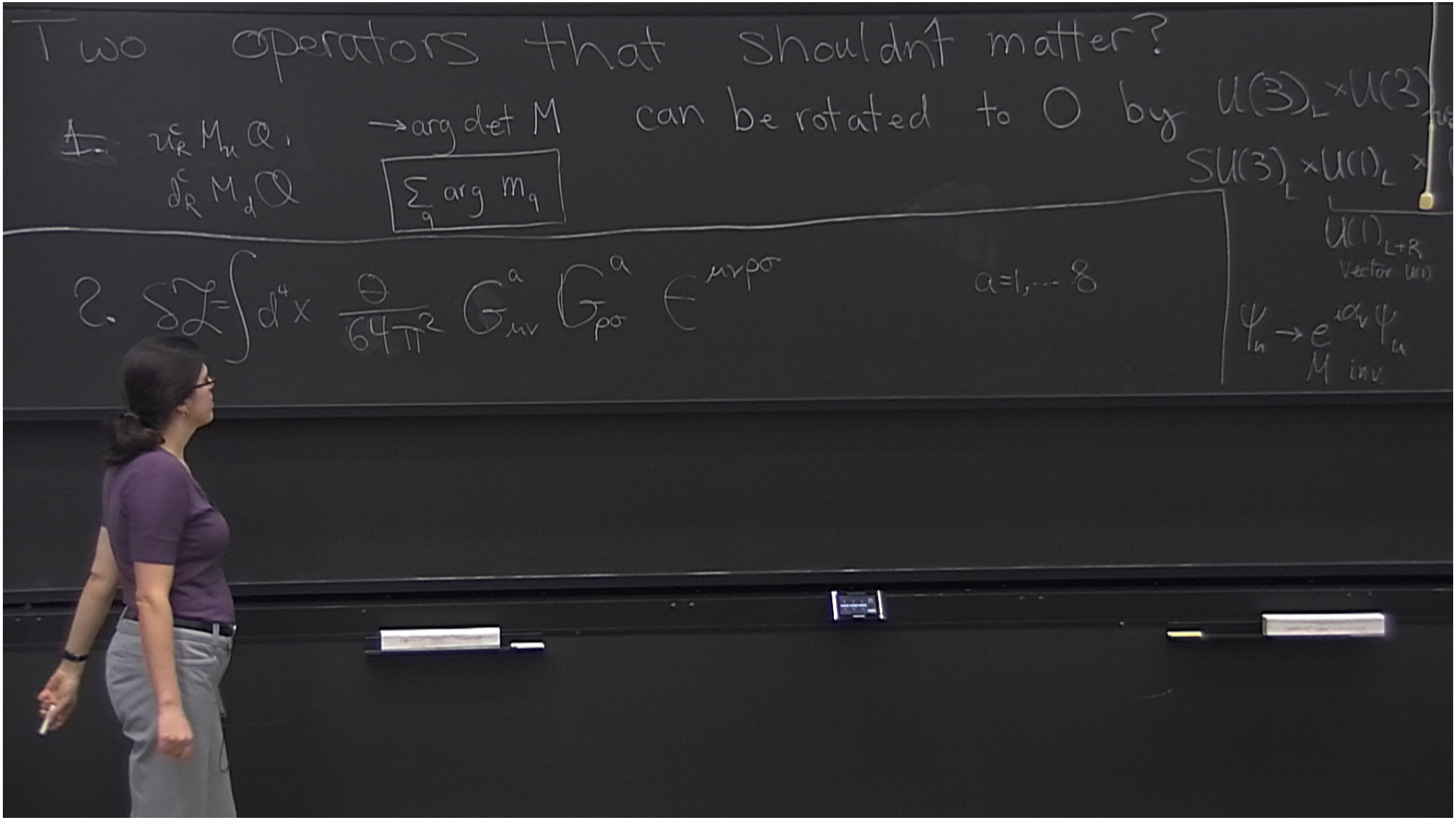

Two operators that sha

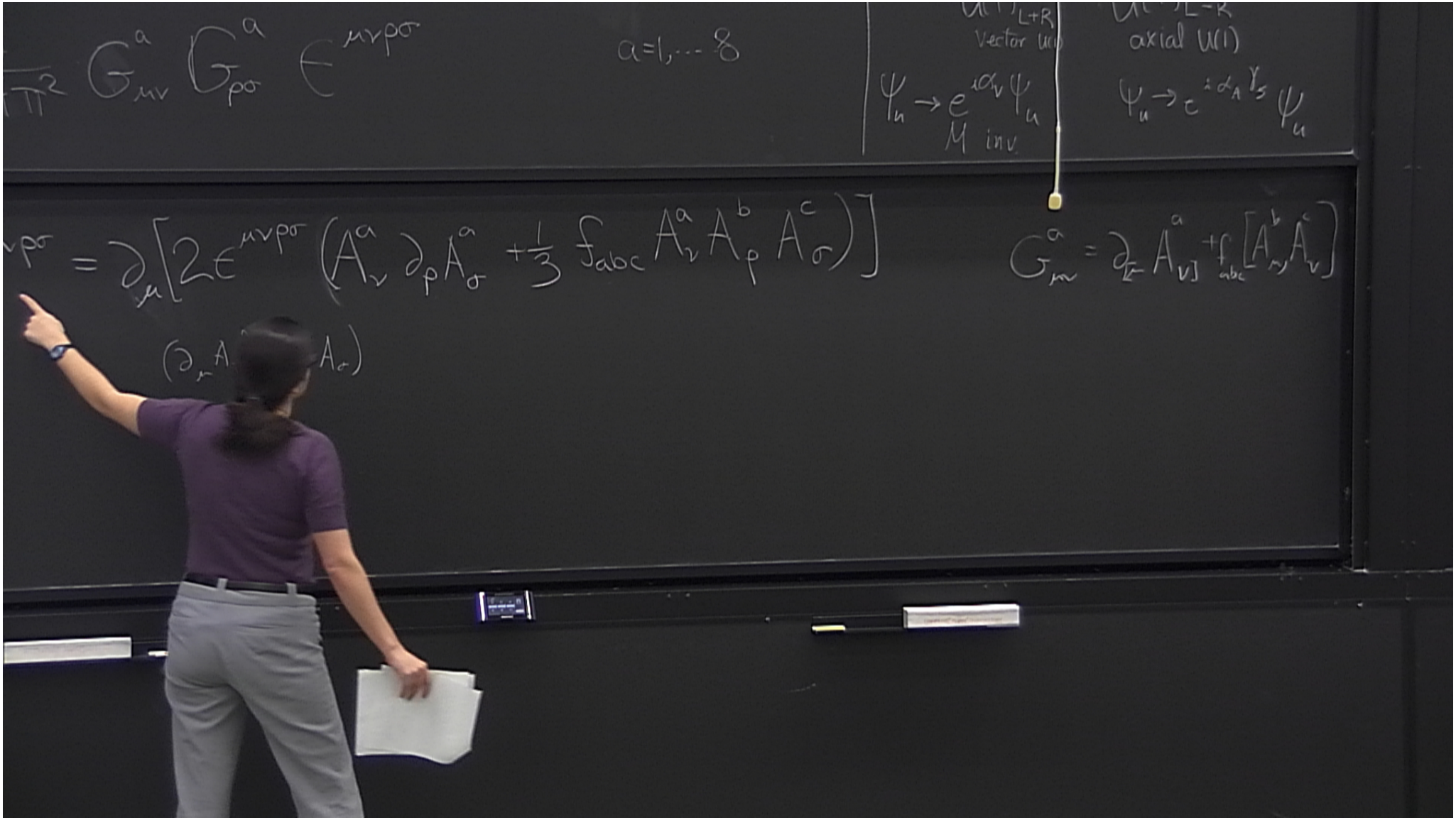

Two operators that shouldn't matter?
→ $v_R^c M_u Q_h$ → arg det M can be rotated to 0 by $U(3)_L \times U(3)_{u_R^c}$ symmetry
$SU(3)_L \times U(1)_L \times U(1)_R \times SU(3)_R$

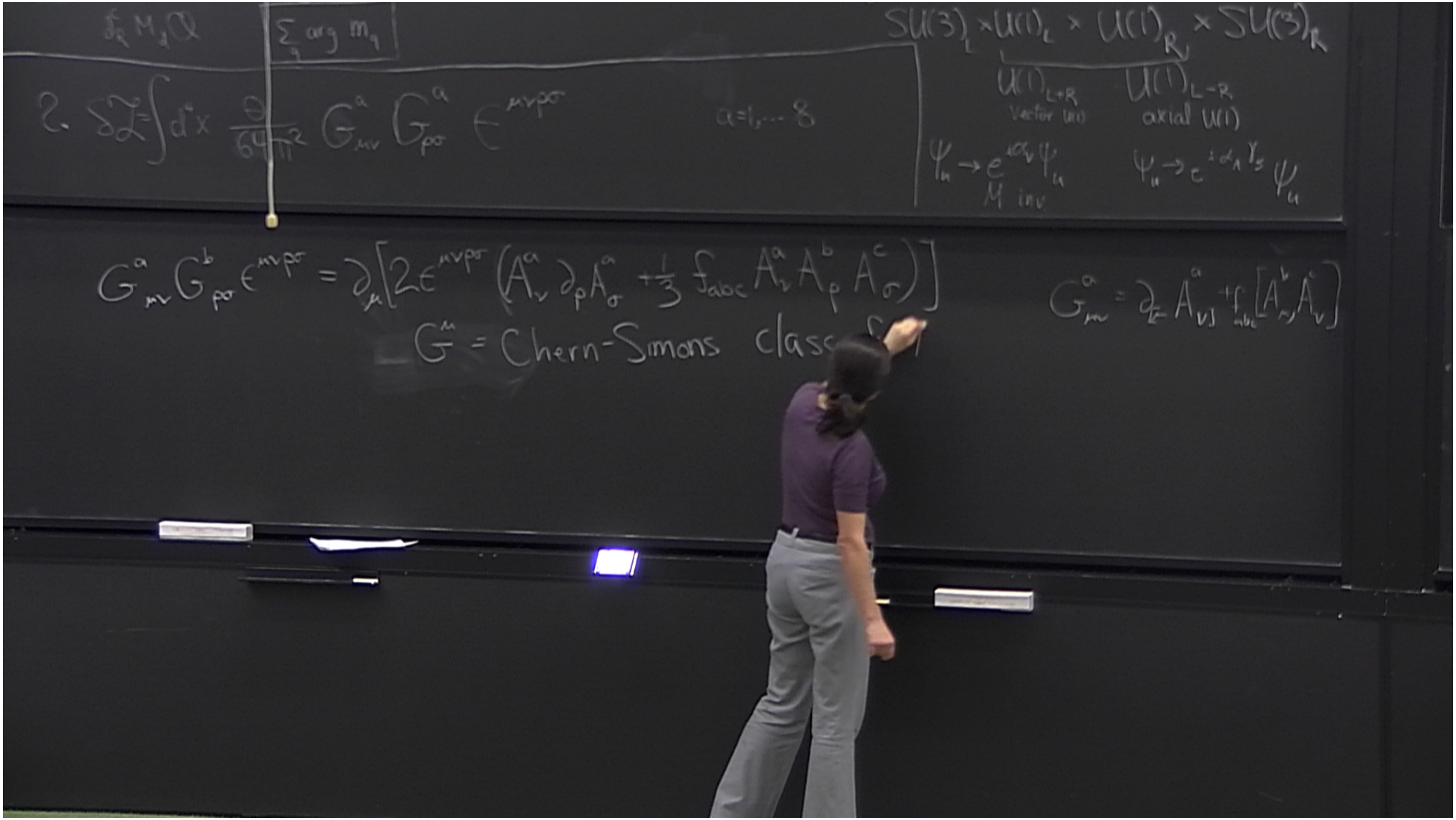

Two operators that shouldn't matter?
→ $\bar{u}_R M_u Q_h$ → arg det M can be rotated to 0 by $U(3)_L \times U(3)_{u_R}$ symmetry
$SU(3)_L \times \cdots \times U(1)_R \times SU(3)_R$

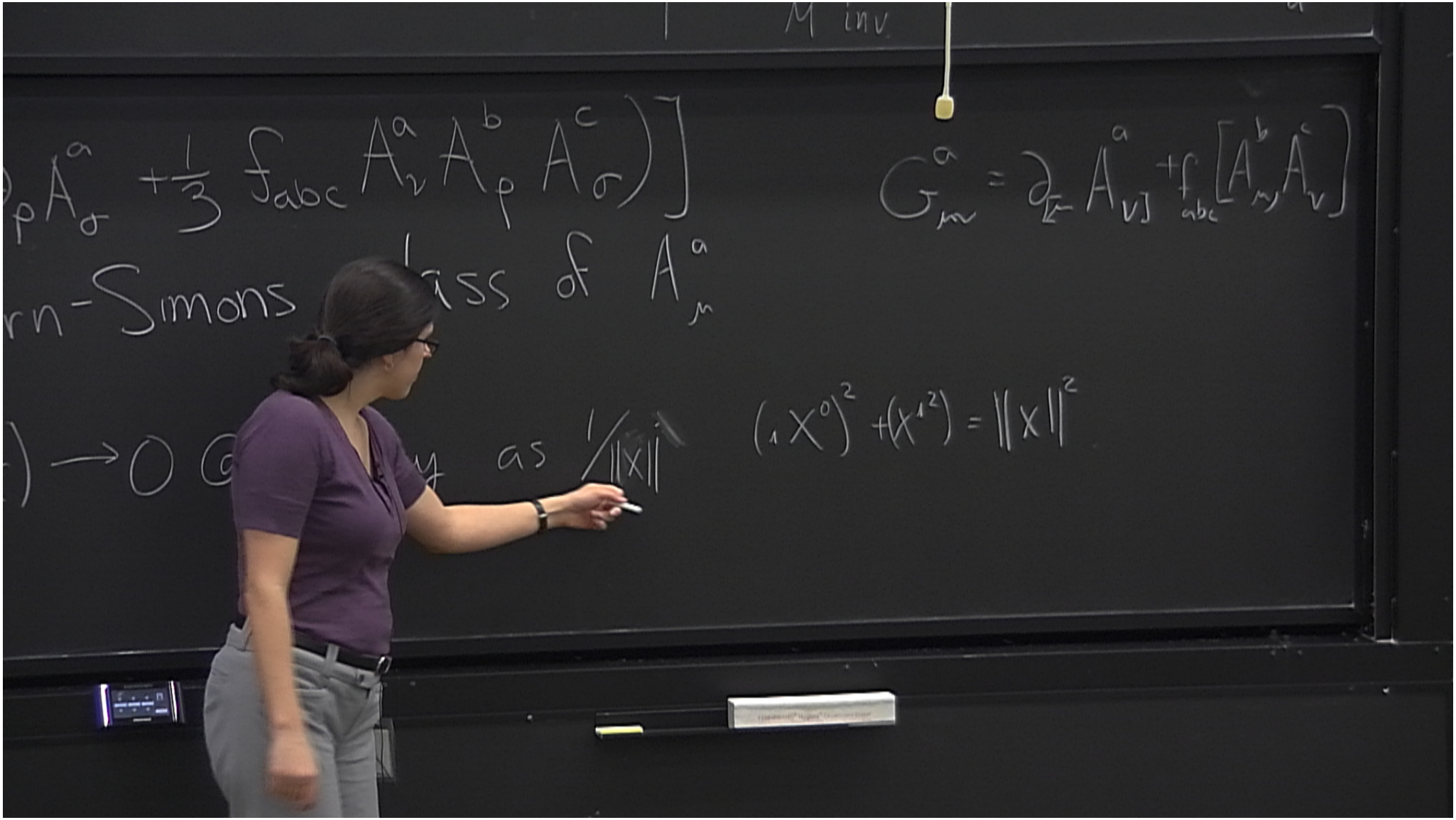

Two operators that shouldn't matter?
→ arg det M can be rotated to 0 by U(
SU(3)

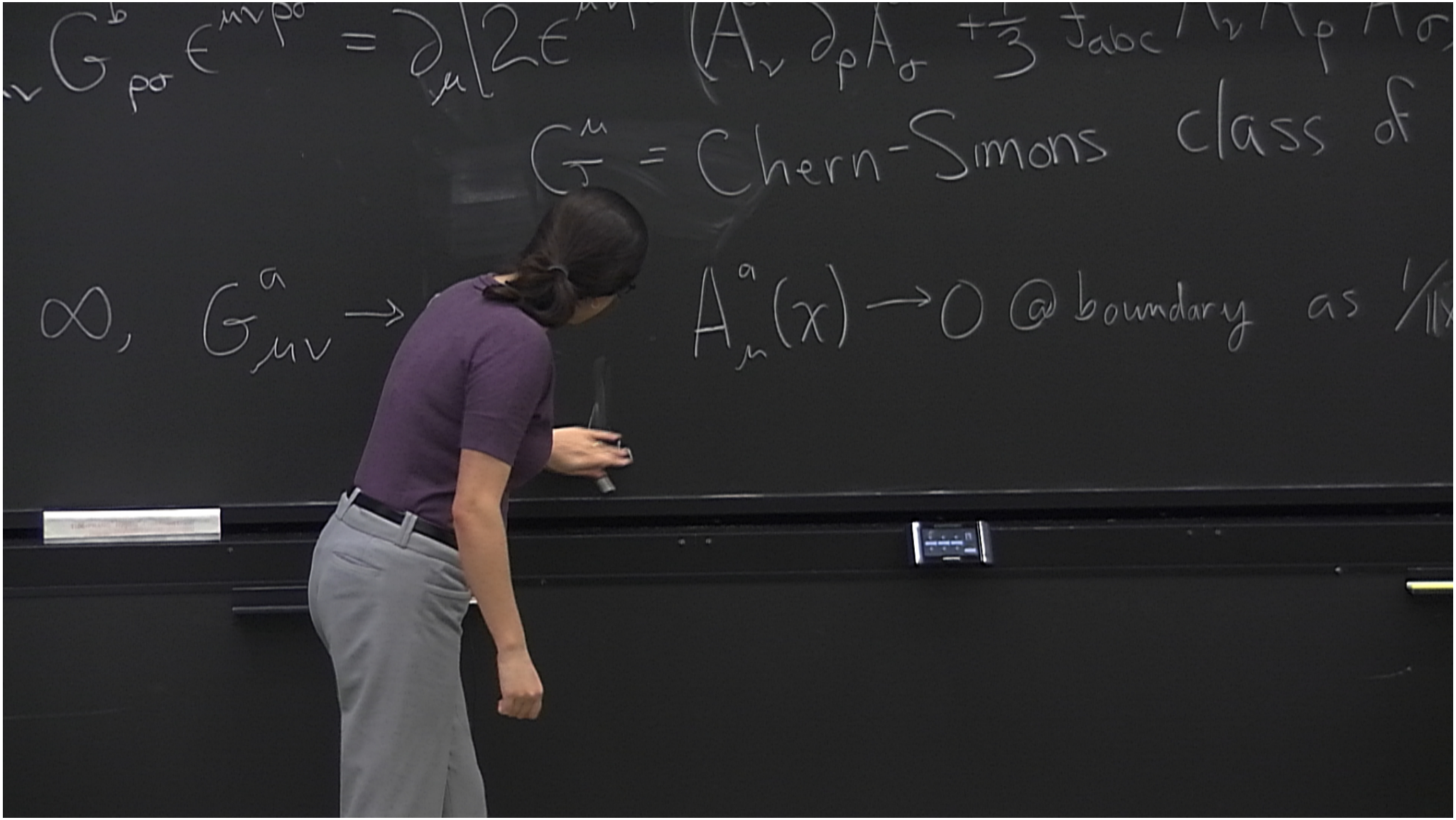

Two operators that shouldn't matter?
1. $\bar{u}^c_R M_u Q$, $\bar{d}^c_R M_d Q$ → arg det M
$\sum_q \arg m_q$
can be rotated to 0 by $U(3)_L \times U(3)$
$SU(3)_L \times U(1)_L \times$
$U(1)_{L+R}$
Vector U(1)
2.
$\psi_u \to e^{i\alpha_u} \psi_u$
M inv.

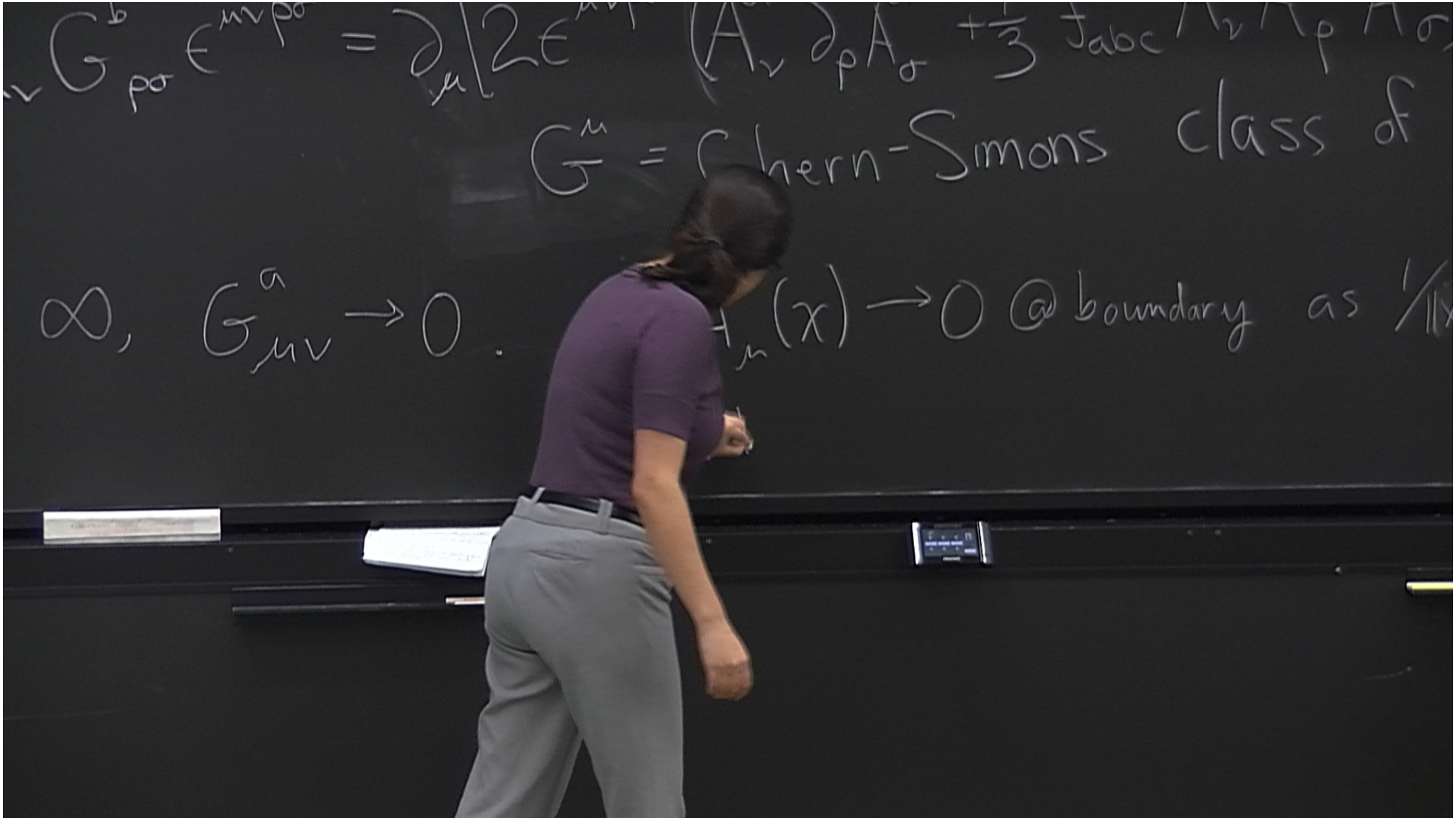

Two operators that shouldn't matter?
1. $\bar{u}^c_R M_u Q$, $\bar{d}^c_R M_d Q$ → arg det M can be rotated to 0 by
$\sum_q \arg m_q$
$U(3)_L \times U(3)$
$SU(3)_L \times U(1)_L \times$
$U(1)_{L+R}$ Vector U(1)
2. $\delta\mathcal{L} = \int d^4x \frac{\theta}{64\pi^2} G^a_{\mu\nu} G^a_{\rho\sigma} \epsilon^{\mu\nu\rho\sigma}$ $a=1,\dots 8$
$\psi_u \to e^{i\alpha\gamma_5}\psi_u$
M inv.

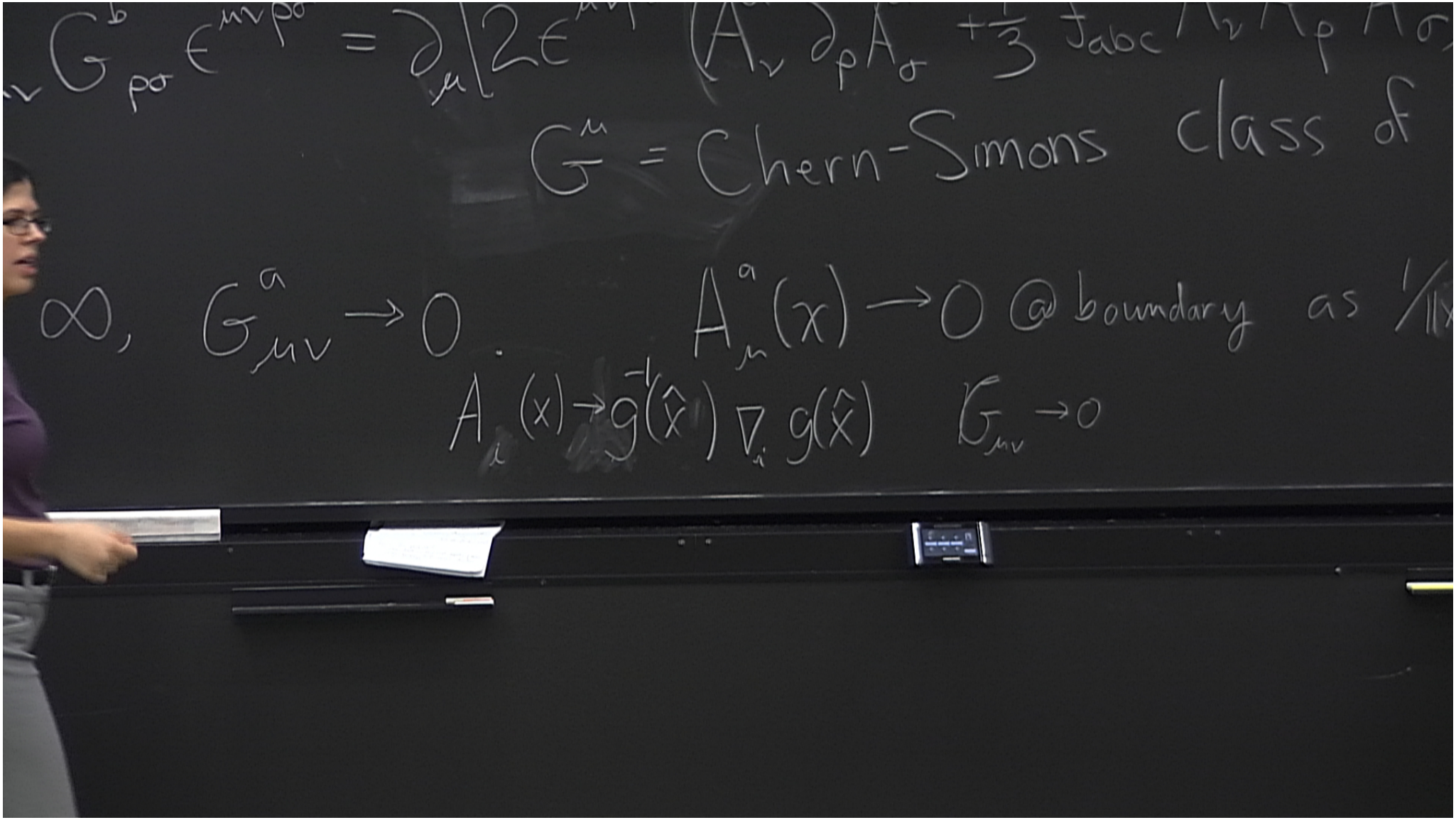

a=1,... 8
L+R
Vector U(1)
axial U(1)
M inv

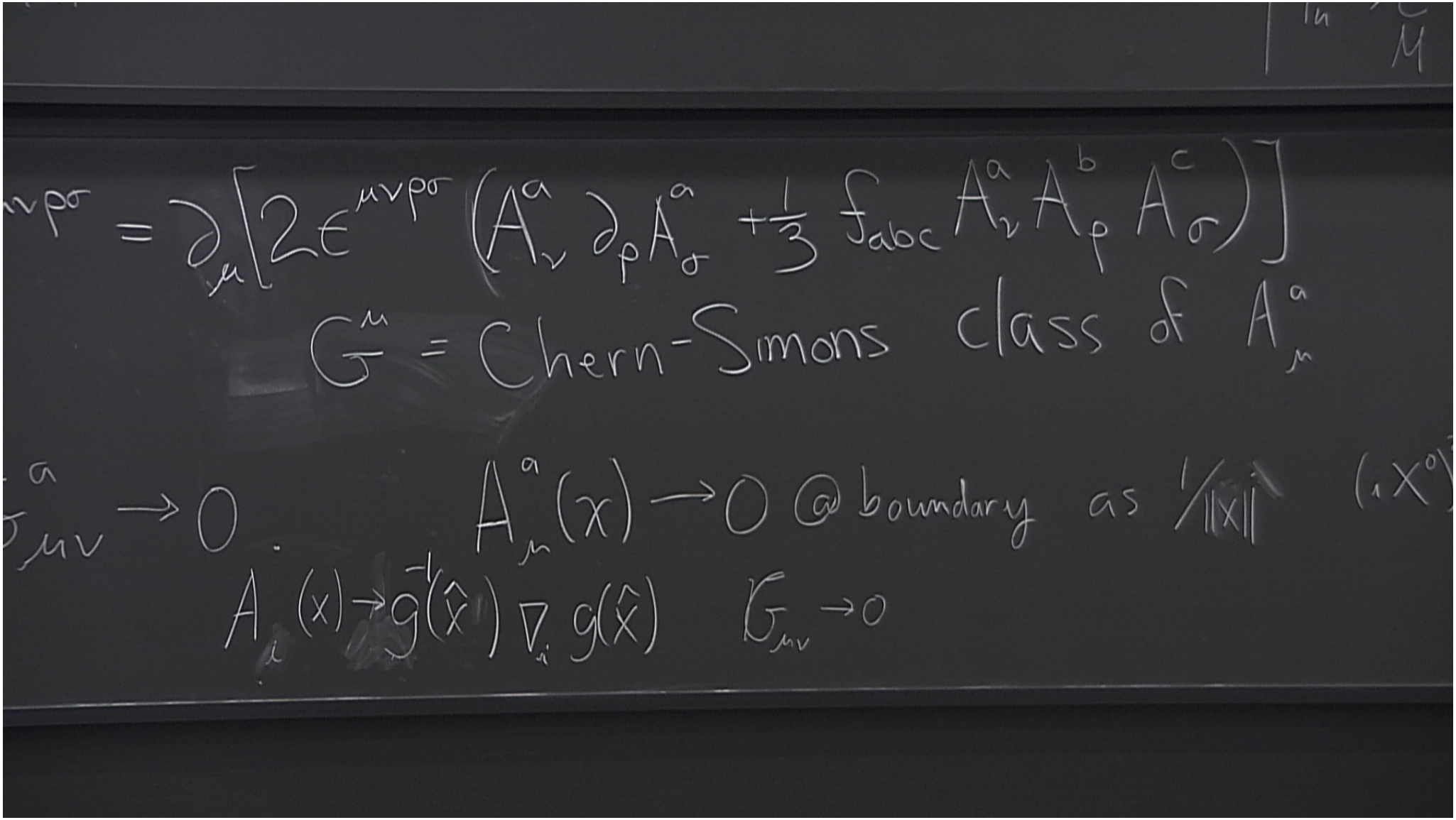

$\delta_\chi M_q$
$\sum_q \arg m_q$
$SU(3)_L \times U(1)_L \times U(1)_R \times SU(3)_R$
$U(1)_{L+R}$ Vector U(1)
$U(1)_{L-R}$ axial U(1)
$\psi_u \to e^{i\alpha_V} \psi_u$ M inv
$\psi_u \to e^{i\alpha_A \gamma_5} \psi_u$
$a = 1, \dots 8$
$G^a_{\mu\nu} G^b_{\rho\sigma} \epsilon^{\mu\nu\rho\sigma} = \partial_\mu [2\epsilon^{\mu\nu\rho\sigma} (A^a_\nu \partial_\rho A^a_\sigma + \frac{1}{3} f_{abc} A^a_\nu A^b_\rho A^c_\sigma)]$
$G^a_{\mu\nu} = \partial_\mu A^a_\nu + f_{abc} [A^b_\mu A^c_\nu]$
G^μ = Chern-Simons

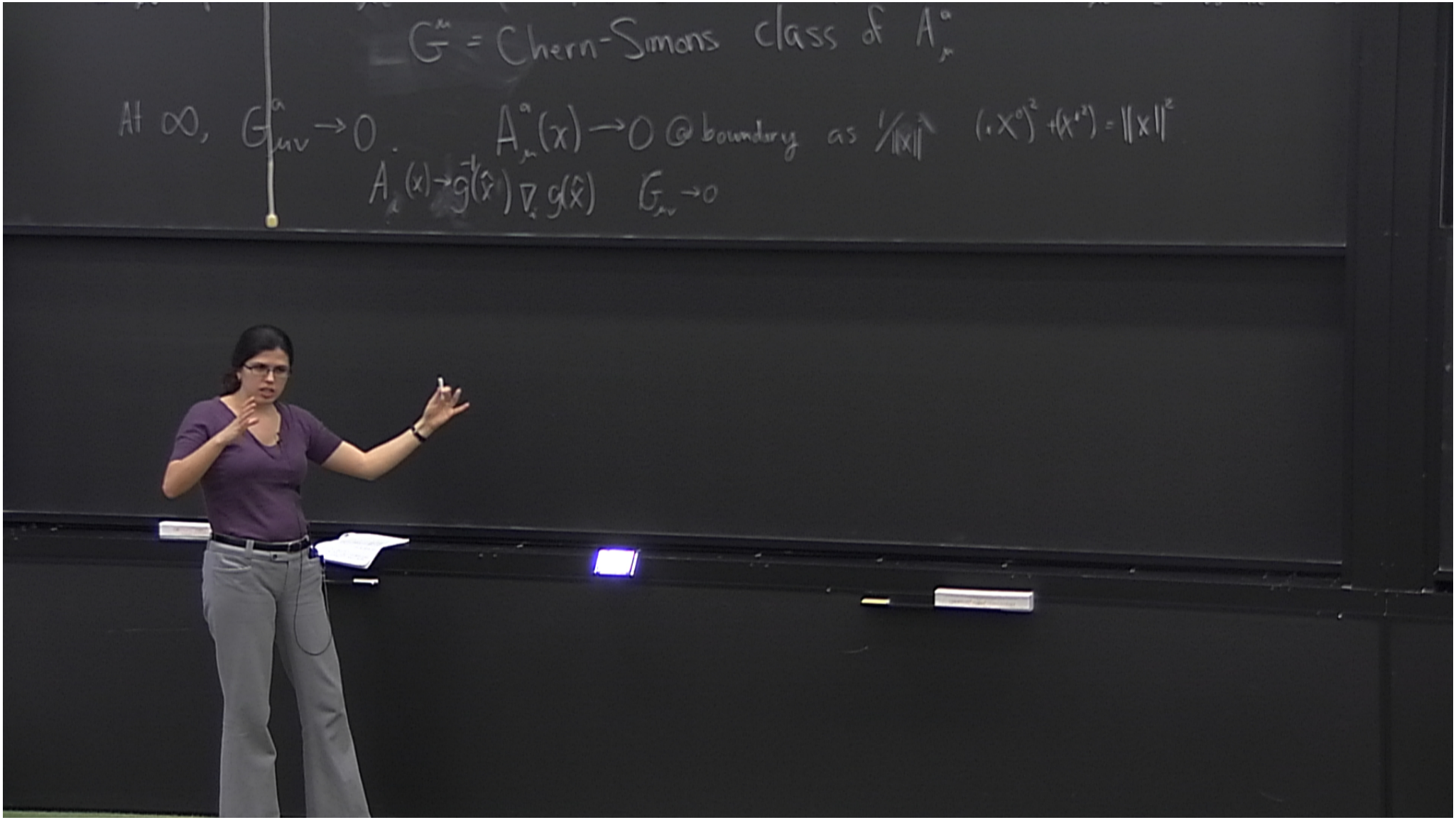

M inv
$\partial_\rho A^a_\sigma + \frac{1}{3} f_{abc} A^a_\nu A^b_\rho A^c_\sigma)]$
$G^a_{\mu\nu} = \partial_\mu A^a_\nu + f_{abc}[A^b_\mu A^c_\nu]$
rn-Simons lass of A^a_μ
$\to 0$ G y as $1/\|x\|$
$(x^0)^2 + (x^1)^2 = \|x\|^2$

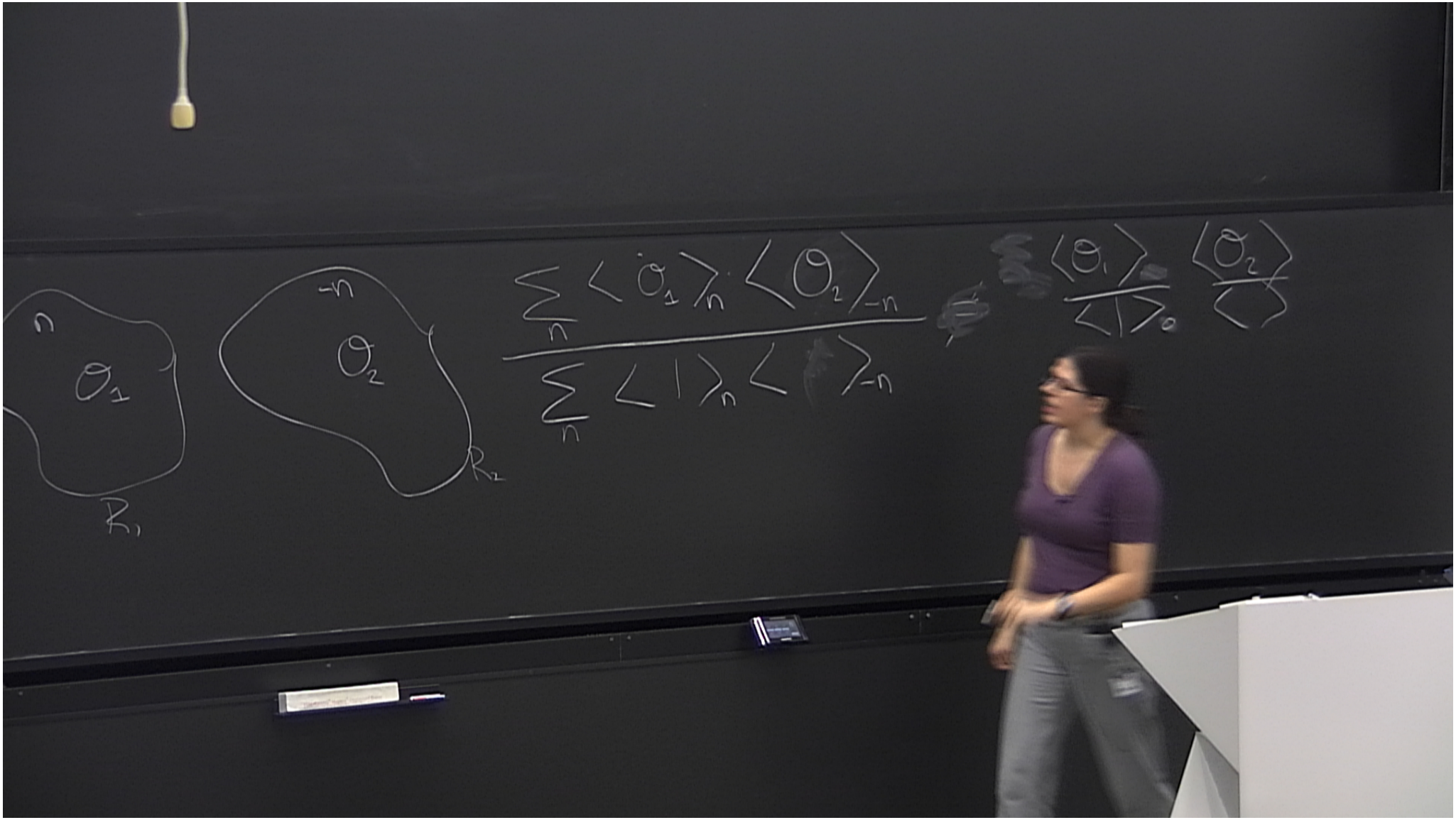

$G^b_{\rho\sigma}\epsilon^{\mu\nu\rho\sigma} = \partial_\mu[2\epsilon^{\ldots}(A_\nu \partial_\rho A_\sigma + \frac{1}{3} f_{abc} A_\nu A_\rho A_\sigma$
G^μ_T = Chern-Simons class of
∞, $G^a_{\mu\nu} \rightarrow$
$A^a_\mu(x) \rightarrow 0$ @ boundary as $1/|x$

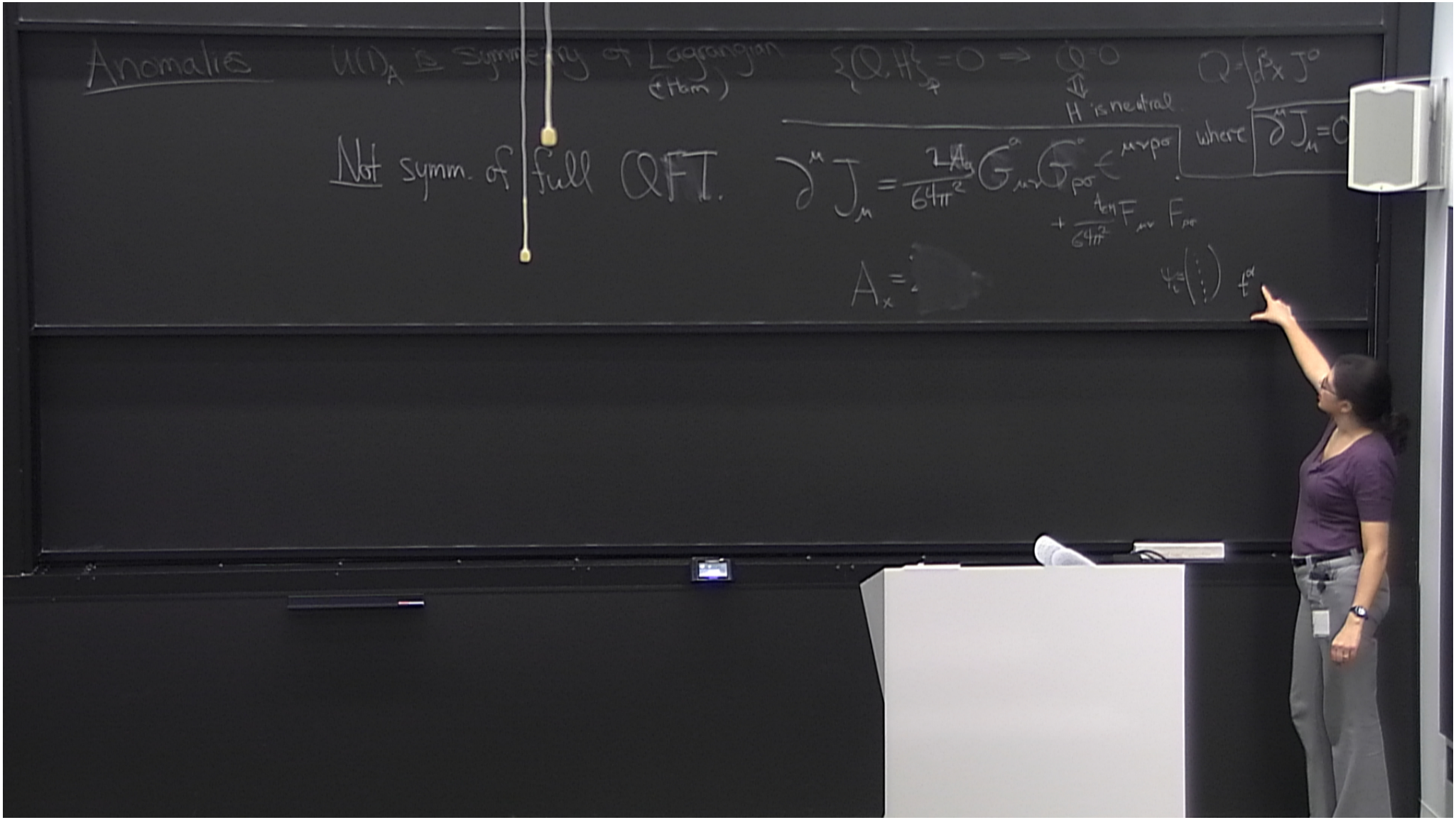

Chern-Simons
class of
@ boundary

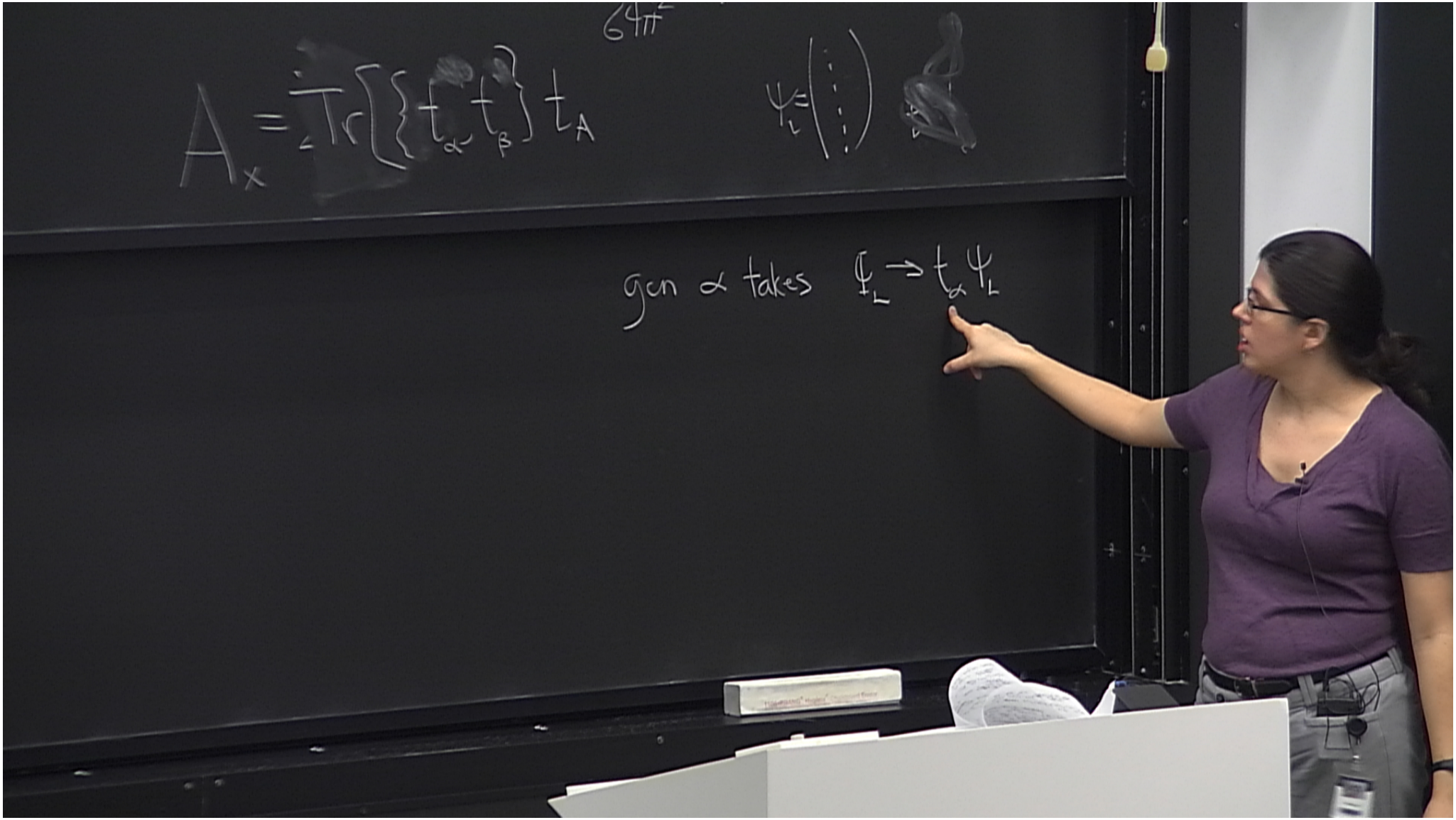

$G^b_{\rho\sigma}\epsilon^{\mu\nu\rho\sigma} = \partial_\mu\left[2\epsilon^{\mu\nu\rho\sigma}\left(A_\nu\partial_\rho A_\sigma + \frac{1}{3}f_{abc}A_\nu A_\rho A_\sigma\right)\right.$
G^μ = Chern-Simons class of
∞, $G^a_{\mu\nu} \to 0$. $A^a_\mu(x) \to 0$ @ boundary as $1/|x|$
$A_i(x) \to g^{-1}(\hat{x})\nabla_i g(\hat{x})$ $G_{\mu\nu} \to 0$

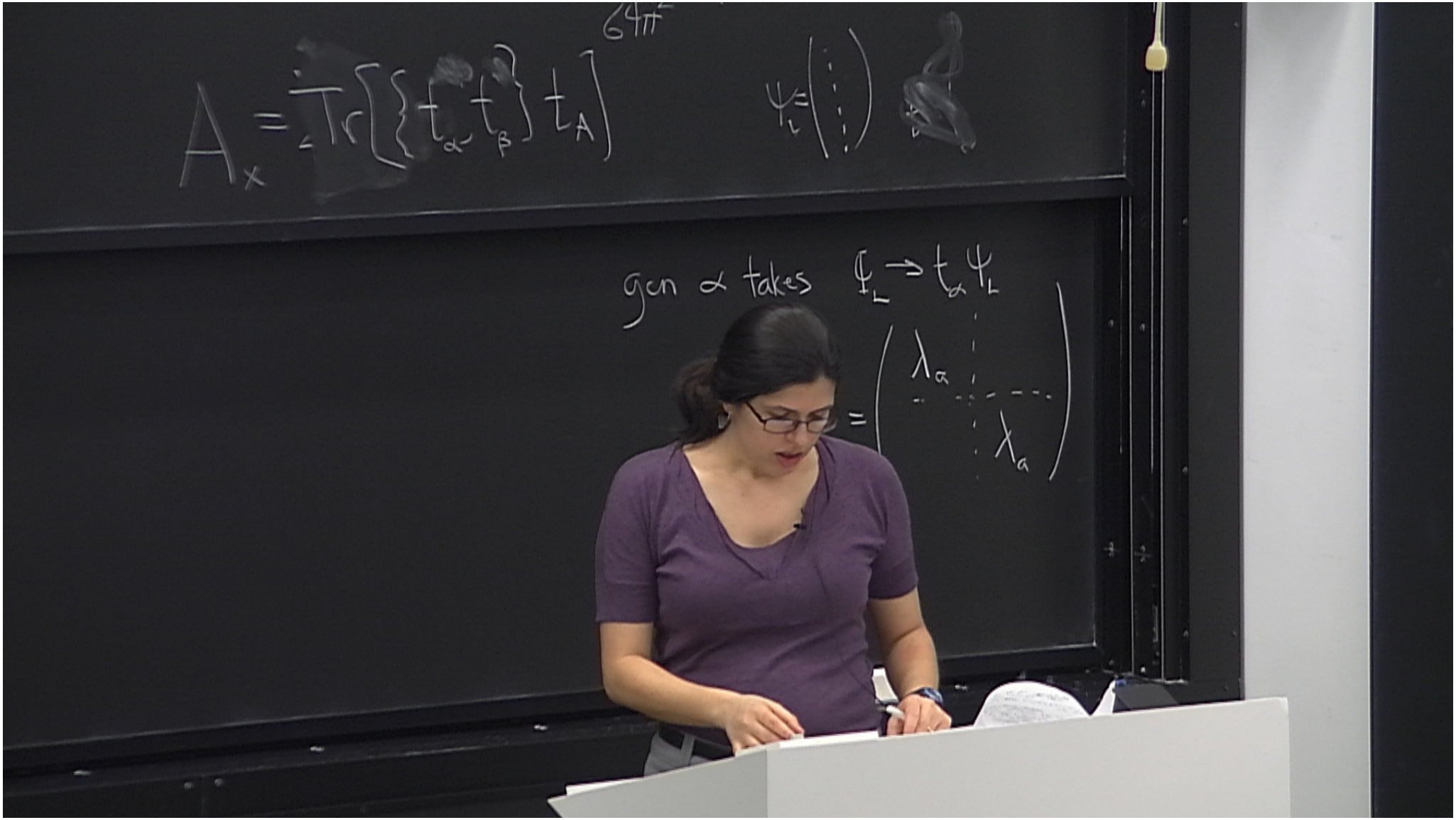

$\nu\rho\sigma} = \partial_\mu \left[2\epsilon^{\mu\nu\rho\sigma} \left(A^a_\nu \partial_\rho A^a_\sigma + \frac{1}{3} f_{abc} A^a_\nu A^b_\rho A^c_\sigma \right) \right]$
G^μ = Chern-Simons class of A^a_μ
$\sigma_{\mu\nu} \to 0$
$A^a_\mu(x) \to 0$ @ boundary as $1/\|x\|$
$A_\mu(x) \to g^{-1}(\hat{x}) \nabla_\mu g(\hat{x})$
$G_{\mu\nu} \to 0$

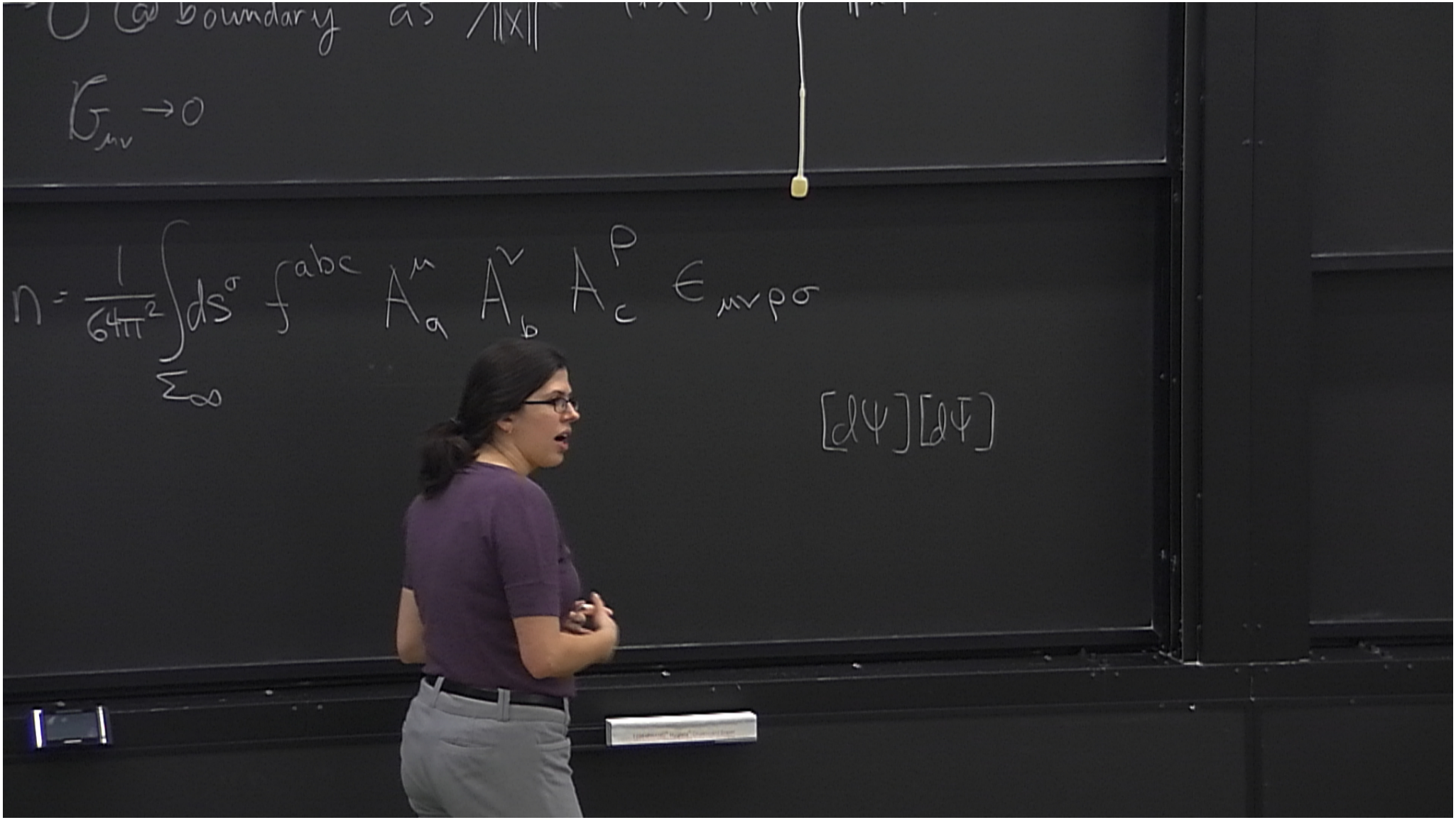

$G^a_{\mu\nu}$ = Chern-Simons class of A^a_μ
At ∞, $G^a_{\mu\nu} \to 0$. $A^a_\mu(x) \to 0$ @ boundary as $1/\|x\|$ $(x^0)^2 + (x^{i=2}) = \|x\|^2$
$A_i(x) \to g^{-1}(\hat{x}) \nabla_i g(\hat{x})$ $G_{\mu\nu} \to 0$

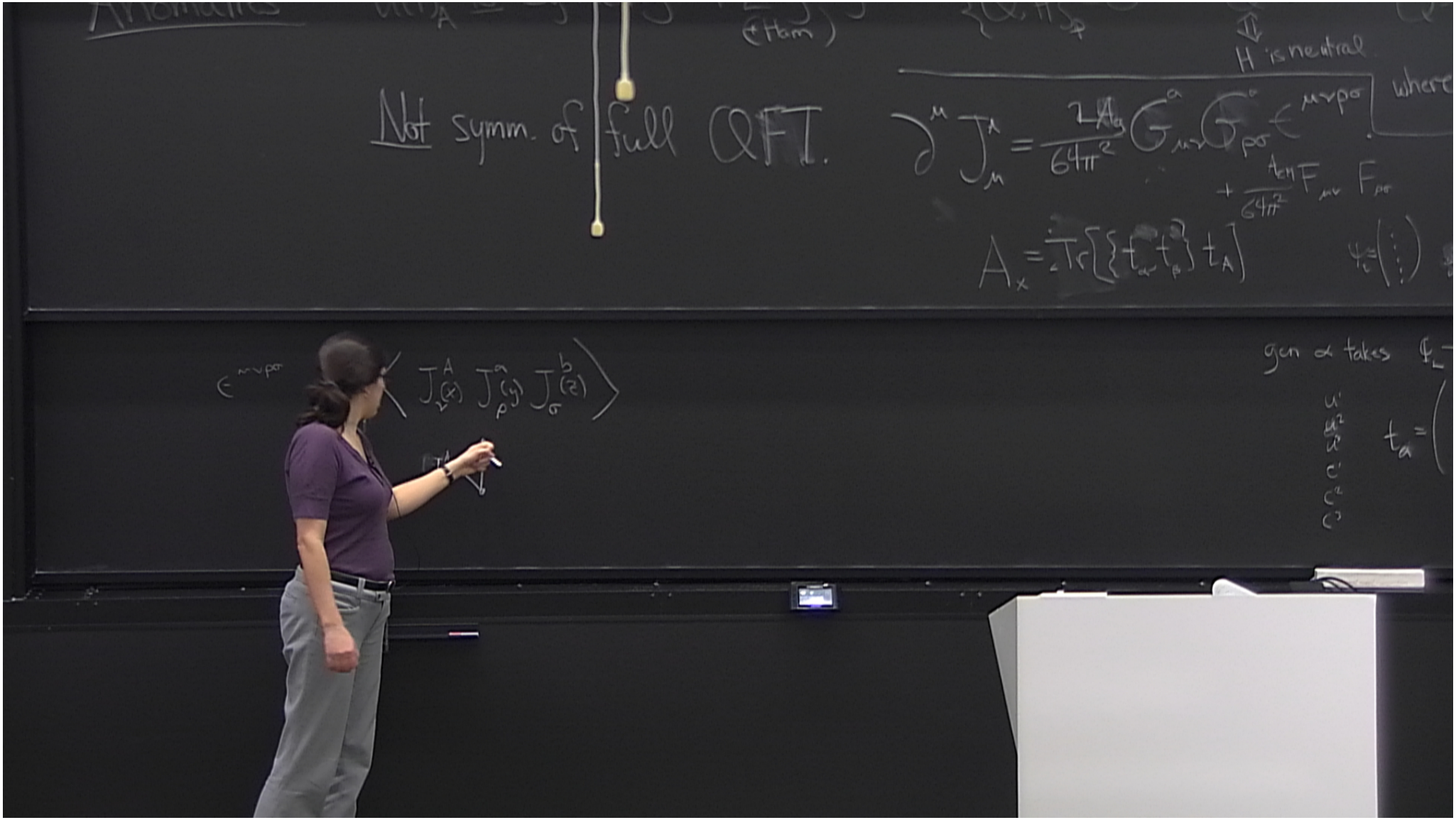

n
O_1
R_1
-n
O_2
R_2
$\frac{\sum_n \langle O_1 \rangle_n \langle O_2 \rangle_{-n}}{\sum_n \langle 1 \rangle_n \langle 1 \rangle_{-n}}$
$= \frac{\langle O_1 \rangle}{\langle 1 \rangle_0} \frac{\langle O_2 \rangle}{\langle 1 \rangle_0}$


Anomalies
$U(1)_A$ is symmetry of Lagrangian (+Ham)
$[Q, H] = 0 \Rightarrow \dot{Q} = 0$
H is neutral
$Q = \int d^3x\, J^0$
Not symm. of full QFT.
$\partial^\mu J_\mu = \frac{2A_g}{64\pi^2} G^a_{\mu\nu} \tilde{G}^a_{\rho\sigma} \epsilon^{\mu\nu\rho\sigma}$
where $\partial^\mu J_\mu = 0$
$+ \frac{A_{em}}{64\pi^2} F_{\mu\nu} \tilde{F}_{\rho\sigma}$
$A_x =$
$\psi = \begin{pmatrix} \vdots \\ \end{pmatrix}$ f^α


$A_x = \frac{1}{64\pi^2} \mathrm{Tr}\left[\left\{t_\alpha, t_\beta\right\} t_A\right]$
$\psi_L = \begin{pmatrix} \vdots \\ \vdots \end{pmatrix}$
gen α takes $\psi_L \to t_\alpha \psi_L$


gen α takes


boundary as
$G_{\mu\nu} \to 0$
$n = \frac{1}{64\pi^2} \int_{\Sigma_\infty} ds^\sigma f^{abc} A^\mu_a A^\nu_b A^\rho_c \epsilon_{\mu\nu\rho\sigma}$
$[d\Psi][d\Psi]$


Not symm. of full QFT.
H is neutral
where
gen α takes