

Title: Discussion 2

Date: Nov 06, 2015 02:00 PM

URL: <http://www.pirsa.org/15110077>

Abstract:

d -dim grav. anomaly \leftrightarrow $d+1$ -dim topo. order

gauge anomaly \leftrightarrow SPT order

$$K = \begin{pmatrix} 2 & 1 & 1 & 1 \\ 1 & 2 & 0 & 0 \\ 1 & 0 & 2 & 0 \\ 1 & 0 & 0 & 2 \end{pmatrix}$$

particles: $e^{i2\pi S_i}$

1	-1	-1	-1
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d -dim $d+1$ -dim
 grav. anomaly \leftrightarrow topo. order
 gauge anomaly \leftrightarrow SPT order

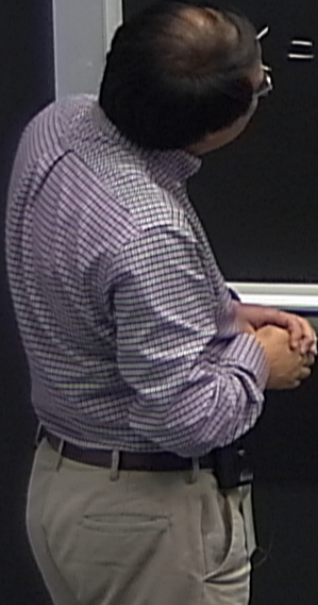
T-SC 3+1D

$$= \begin{pmatrix} 2 & 1 & 1 & 1 \\ 1 & 2 & 0 & 0 \\ 1 & 0 & 2 & 0 \\ 1 & 0 & 0 & 2 \end{pmatrix}$$

e charges:

particles:

1	-1	-1	-1
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T-SC 3+1D

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e particles:

particles:

1	-1	-1	-1
---	----	----	----

CAUTION

d -dim
gauge anomaly \leftrightarrow $d+1$ -dim
topo. order

gauge anomaly \leftrightarrow SPT order

T-SC 3+1D

$$K = \begin{pmatrix} 2 & 1 & 1 & 1 \\ 1 & 2 & 0 & 0 \\ 1 & 0 & 2 & 0 \\ 1 & 0 & 0 & 2 \end{pmatrix}$$

\downarrow
 $-K$

particles:

e ions:

1	-1	-1	-1
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 grav. anomaly \leftrightarrow topo. order
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T-SC 3+1D

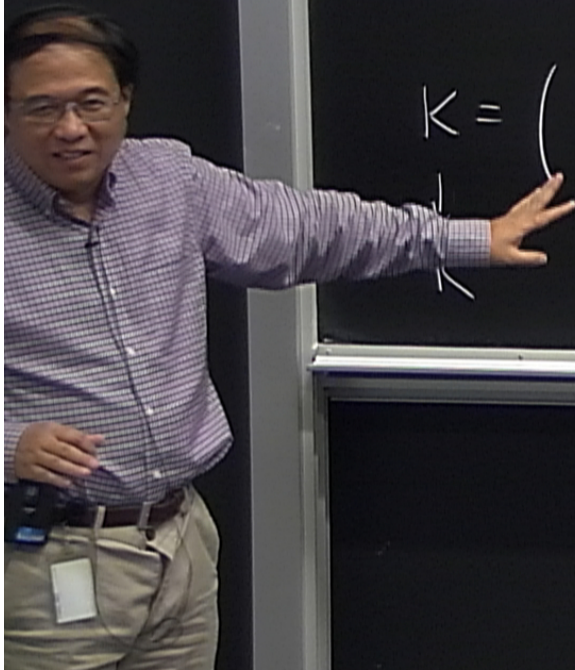
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particles:

e ions:

1	-1	-1	-1
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2+1 dim



d -dim \leftrightarrow $d+1$ -dim
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 gauge anomaly \leftrightarrow SPT order

T-SC 3+1D

$$K = \begin{pmatrix} 2 & 1 & 1 & 1 \\ 1 & 2 & 0 & 0 \\ 1 & 0 & 2 & 0 \\ 1 & 0 & 0 & 2 \end{pmatrix}$$

\downarrow
 $-K$

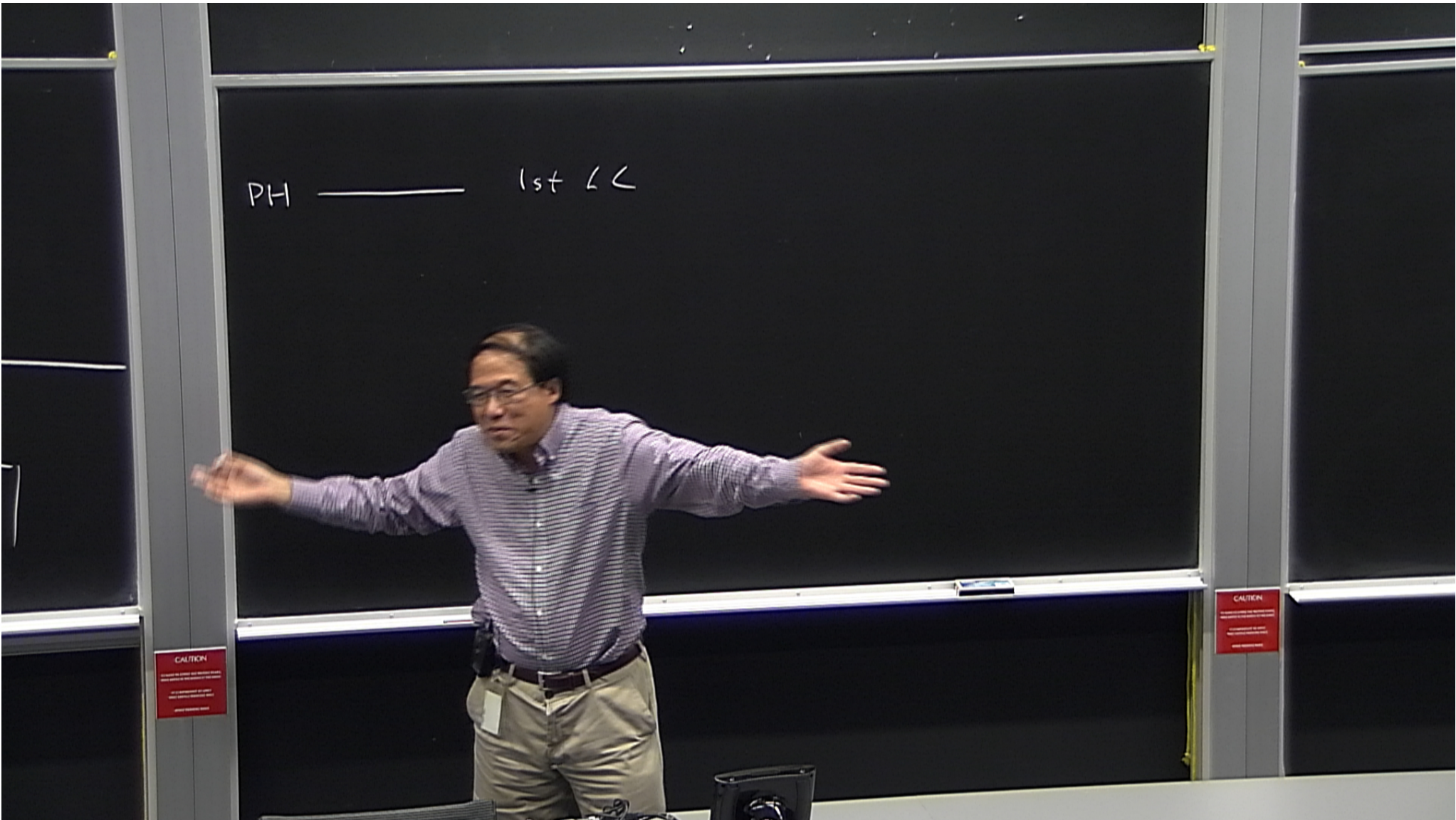
2+1 dim

particles:

$e^{i2\pi s}$

1	-1	-1	-1
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CAUTION

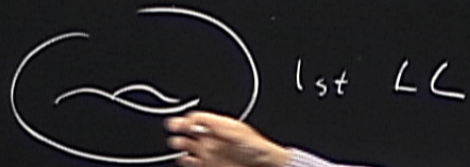


PH _____ 1st LL

CAUTION
Do not touch the screen or the bezel.
The screen is fragile and may be damaged.
Do not use sharp objects to clean the screen.
Use a soft, lint-free cloth.

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PH _____ 1st LL



N_4

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T-SC 3+1D

$$K = \begin{pmatrix} 2 & 1 & 1 & 1 \\ 1 & 2 & 0 & 0 \\ 1 & 0 & 2 & 0 \\ 1 & 0 & 0 & 2 \end{pmatrix}$$

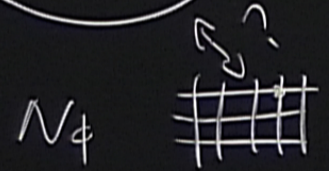
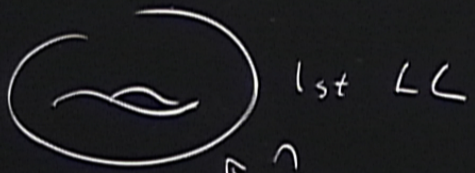
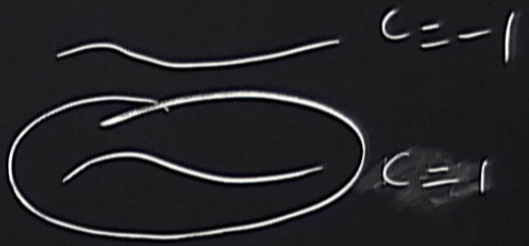
2+1 dim

particles:

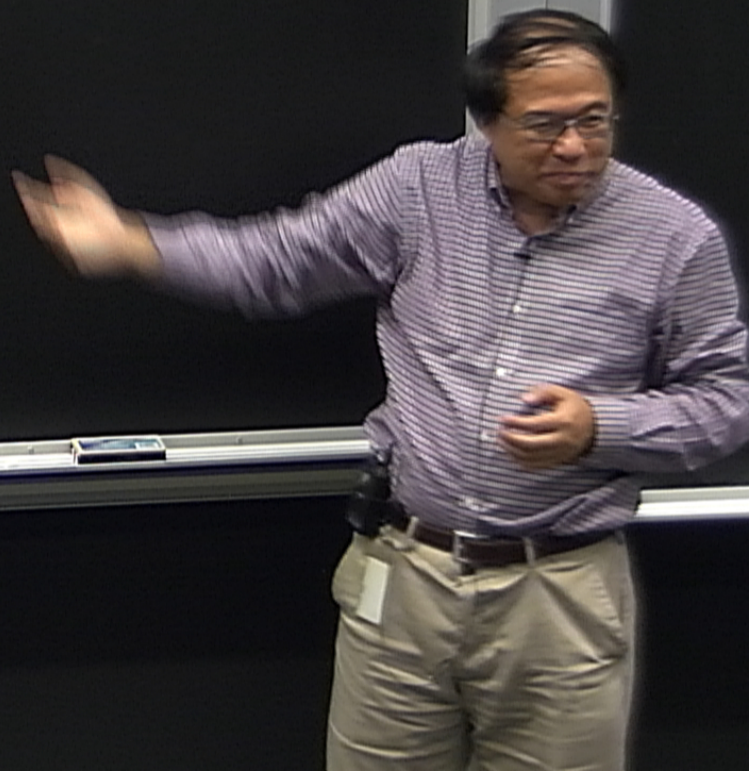
$e^{i2\pi S}$

1	-1	-1	-1
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PH ——— 1st LL

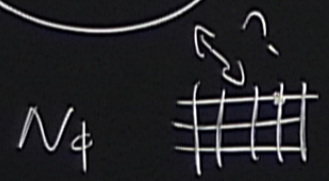
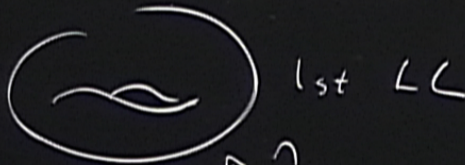
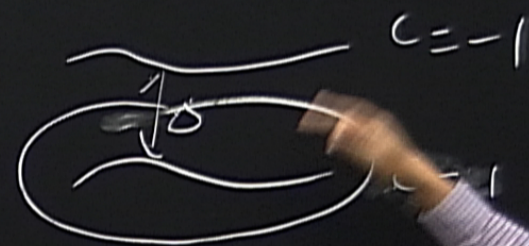


$$\frac{V_{tot} = \otimes_i V_i}{(PH) = \prod_i PH_i}$$



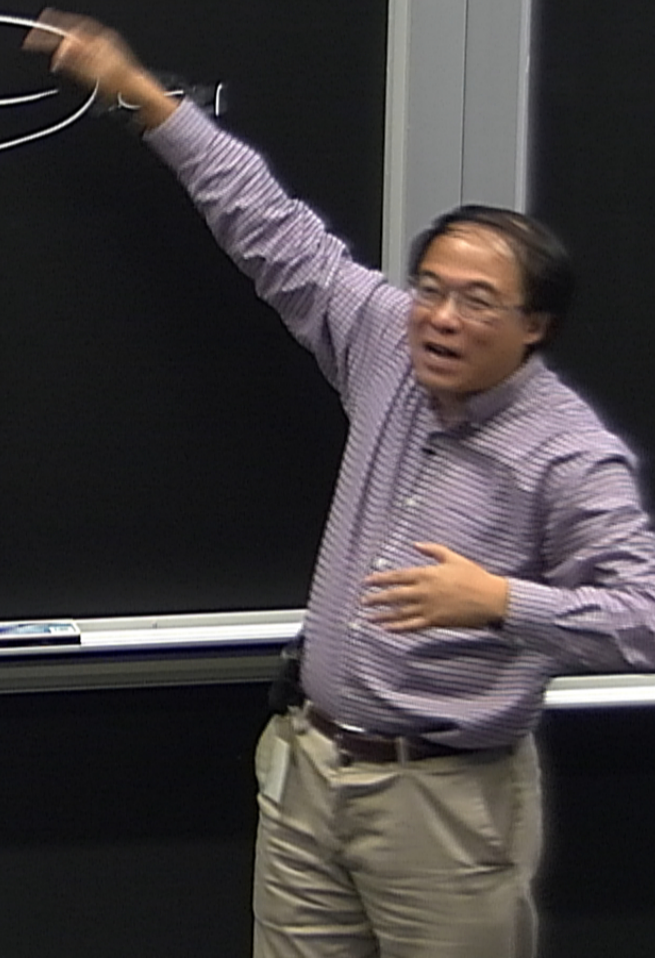
CAUTION
DO NOT TOUCH THE BOARD WHEN IT IS HOT
IT IS EXTREMELY HOT AND MAY BURN YOUR SKIN
PLEASE BE CAREFUL

PH ——— 1st LL



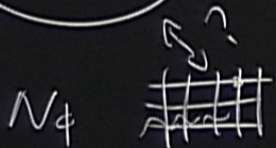
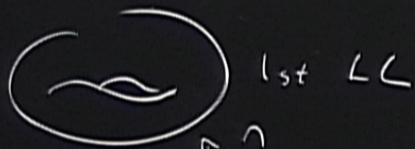
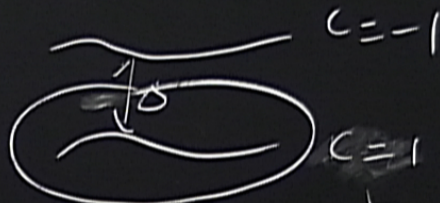
$$V_{tot} = \otimes, V_i \leftarrow$$

$$\textcircled{PH} = \prod PH_i$$



CAUTION
 DO NOT TOUCH THE BOARD OR THE BOARD ERASER.
 IT IS DANGEROUS TO TOUCH THE BOARD ERASER.
 PLEASE BE CAREFUL.

PH ——— 1st LL

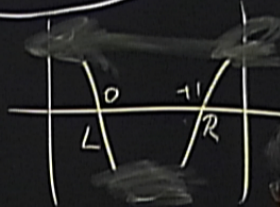


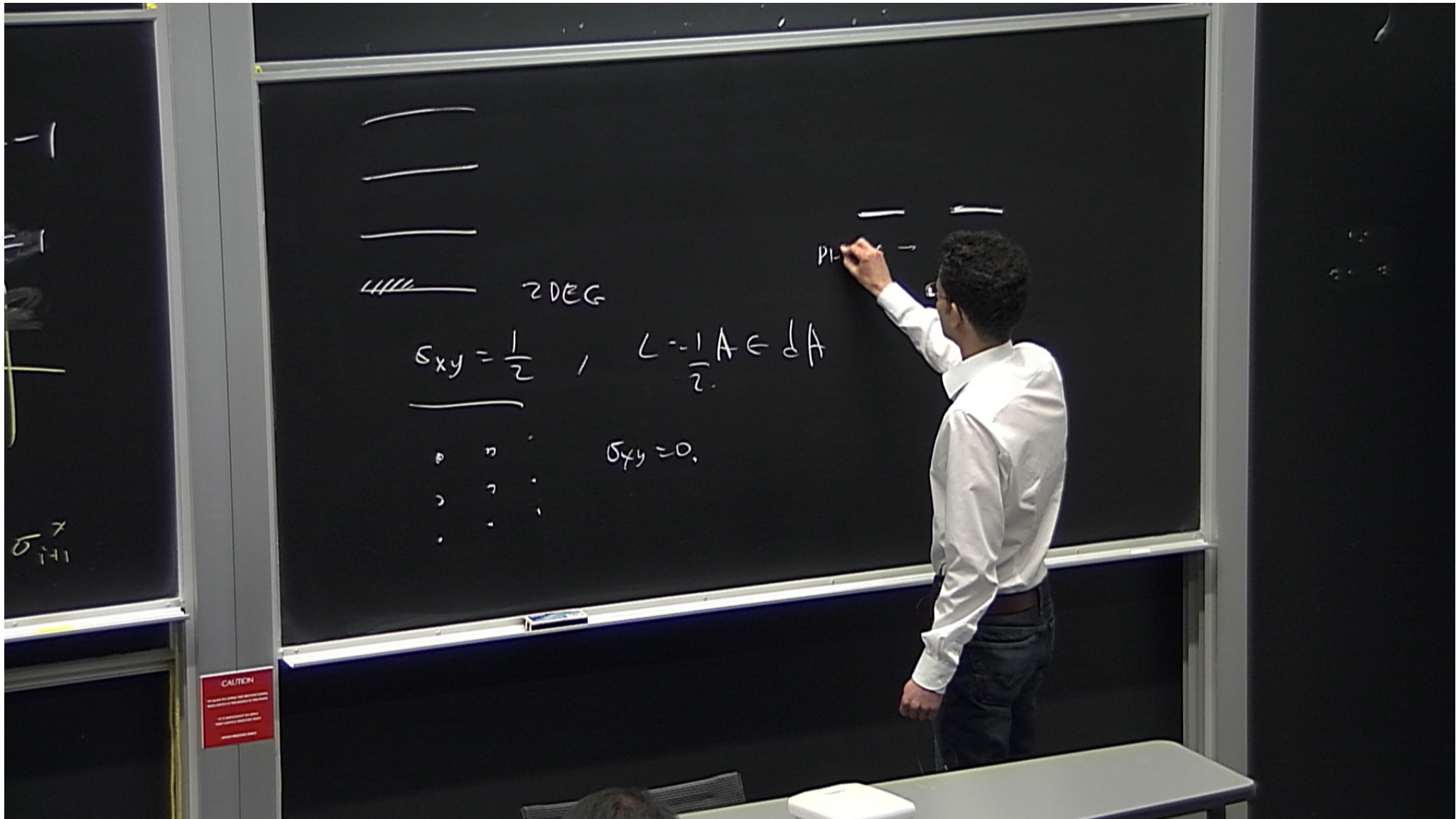
$$V_{tot} = \otimes, V_i \leftarrow$$

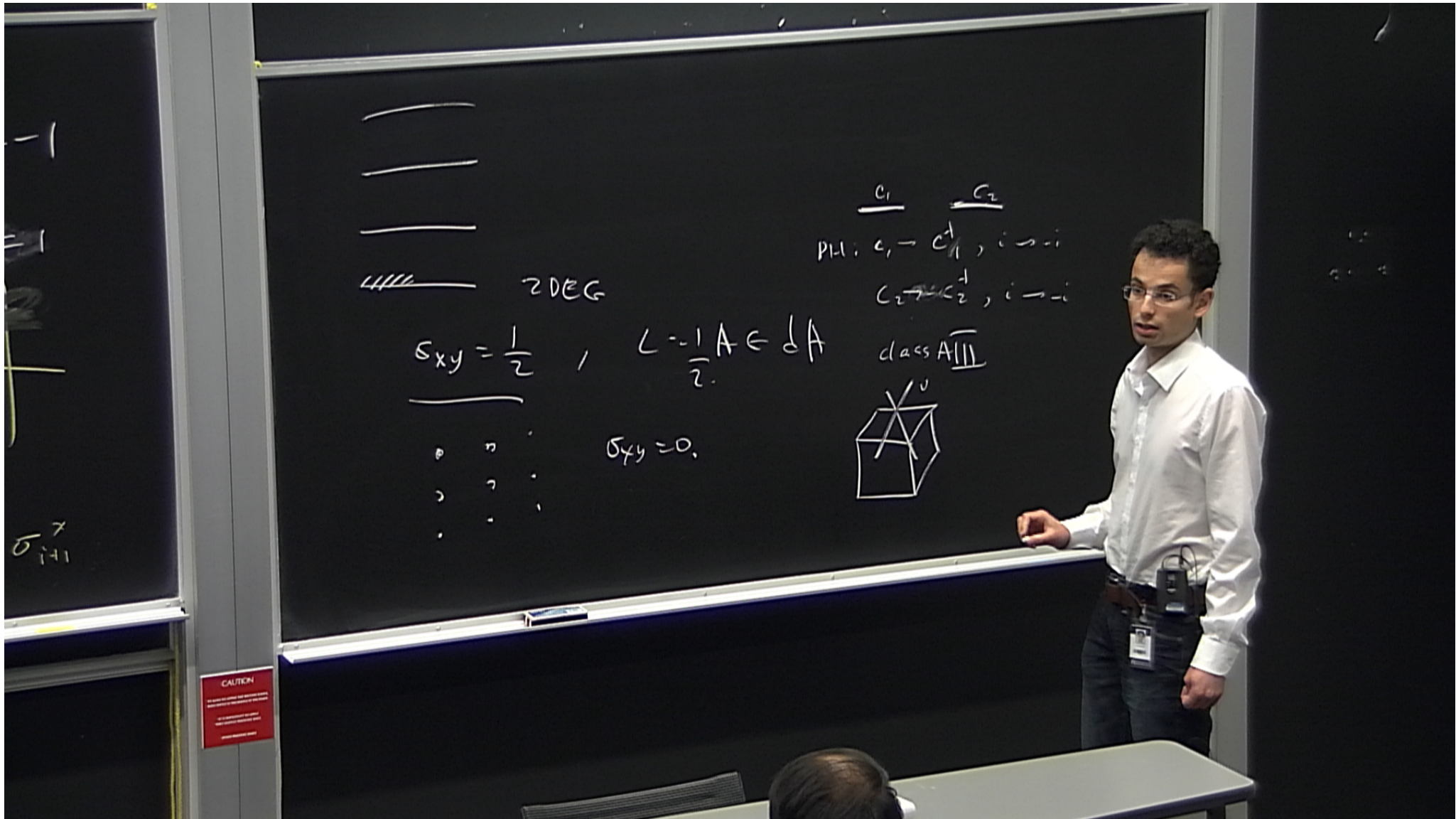
$$PH = \prod_i PH_i$$

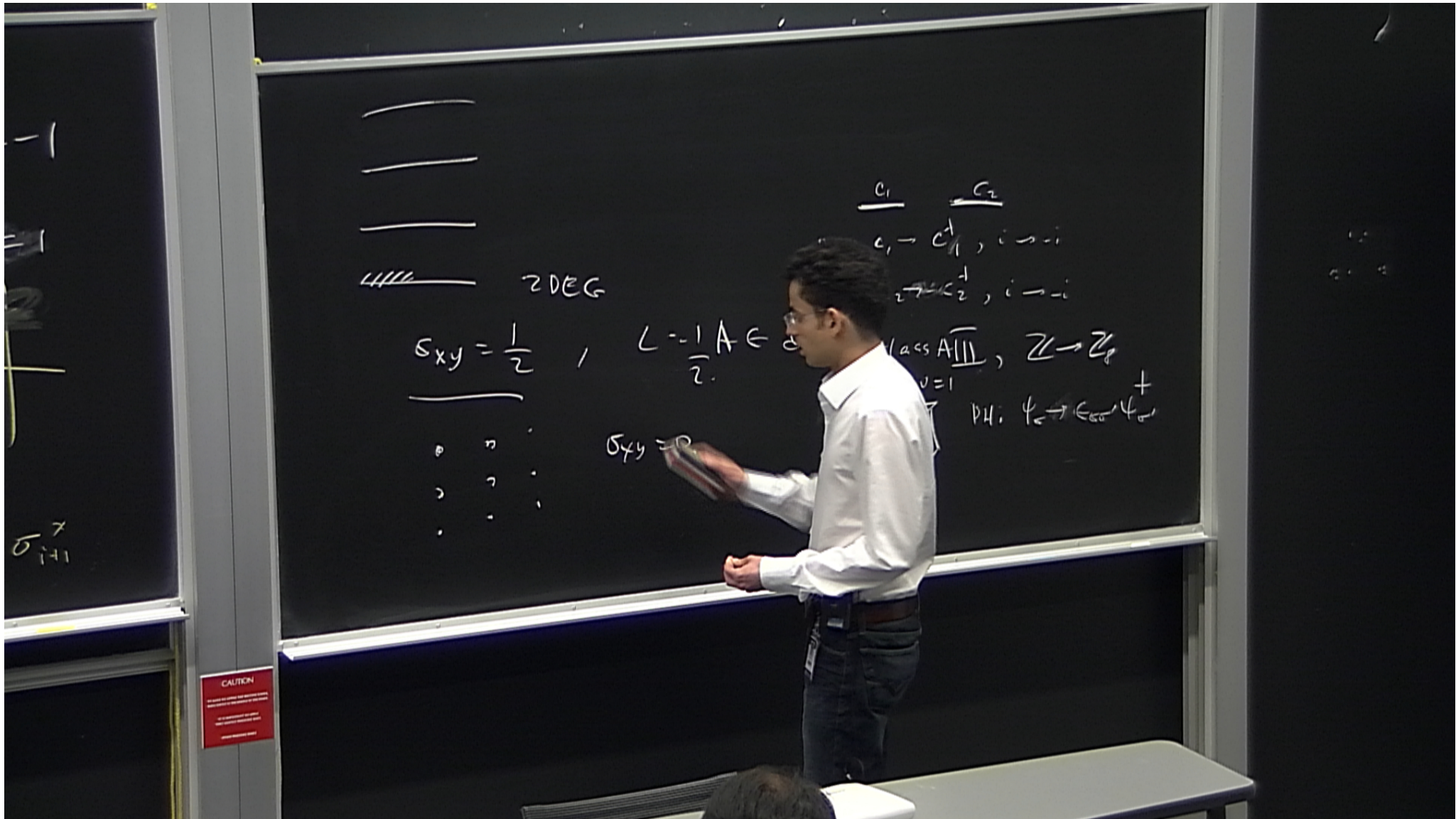
$$\prod \omega(i, j, k)$$

$$\sigma_i \sigma_j$$









\emptyset
 $\ell = 10$

TI,

X

$T: \mathcal{U}_G \rightarrow \mathcal{C}_{\text{sur}} \mathcal{U}_G, \mathcal{U}(1)$
 T -Pfaffian

$I_{\text{sing}} \times \mathcal{U}(1)_{-8}$

	0	1	2	3	4	5	6	7
1	1	X		X				
5	X		X		X			X
4	X	X		X		X		X

○
l-odd

TI,

X

T: $4_6 \rightarrow 6_{66} 4_6, U(1)$

coeff. an

I side $U(1)_{-8}$

	2	3	4	5	6	7
1	-	X	1	X	-	
X	1	X	-1	X	-1	X
-1	X	1	+	-1	+	+

○
l - odd

TI,
X

T: $4s \rightarrow 4s, 4p, 4d, 4f$, $U(1)_{EM}$
T - Pfaff. an

$$\psi_{EM} = \frac{k}{r}$$

$I \sin \theta \times U(1)_{-8}$

	0	1	2	3	4	5	6	7
1	1	X	-	X	1	X	-	X
2	X	1	X	-	X	-	X	1
3	X	X	1	+	-	+	-	+

↑
electron

\bigcirc
 l - odd

$TI,$
 X


$T: \mathcal{U}_G \rightarrow \mathcal{C}_{\text{ev}}, \mathcal{U}_G, \mathcal{U}(1)_{EM}$
 T -Pfaff. an

$$\psi_{EM} = \frac{k}{4}$$

$I \text{ sing } X \mathcal{U}(1)_{-8}$

	0	1	2	3	4	5	6	7
1	1	X	-	X	1	X	-	X
2	X	1	X	-	X	-	X	1
3	X	X	1	+	-	+	-	+
4	+				-			+


 $l - \text{odd}$

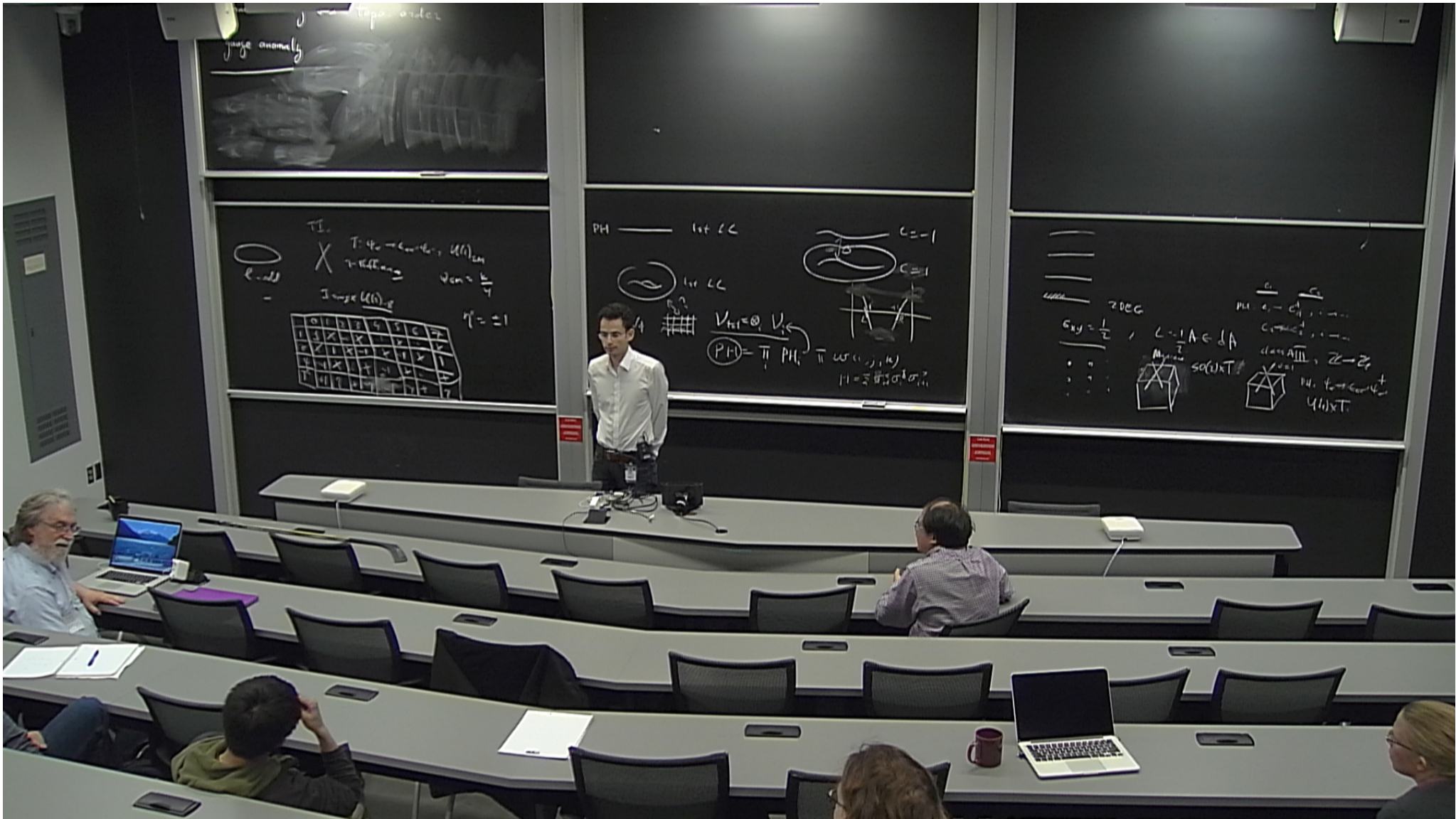
$TI,$


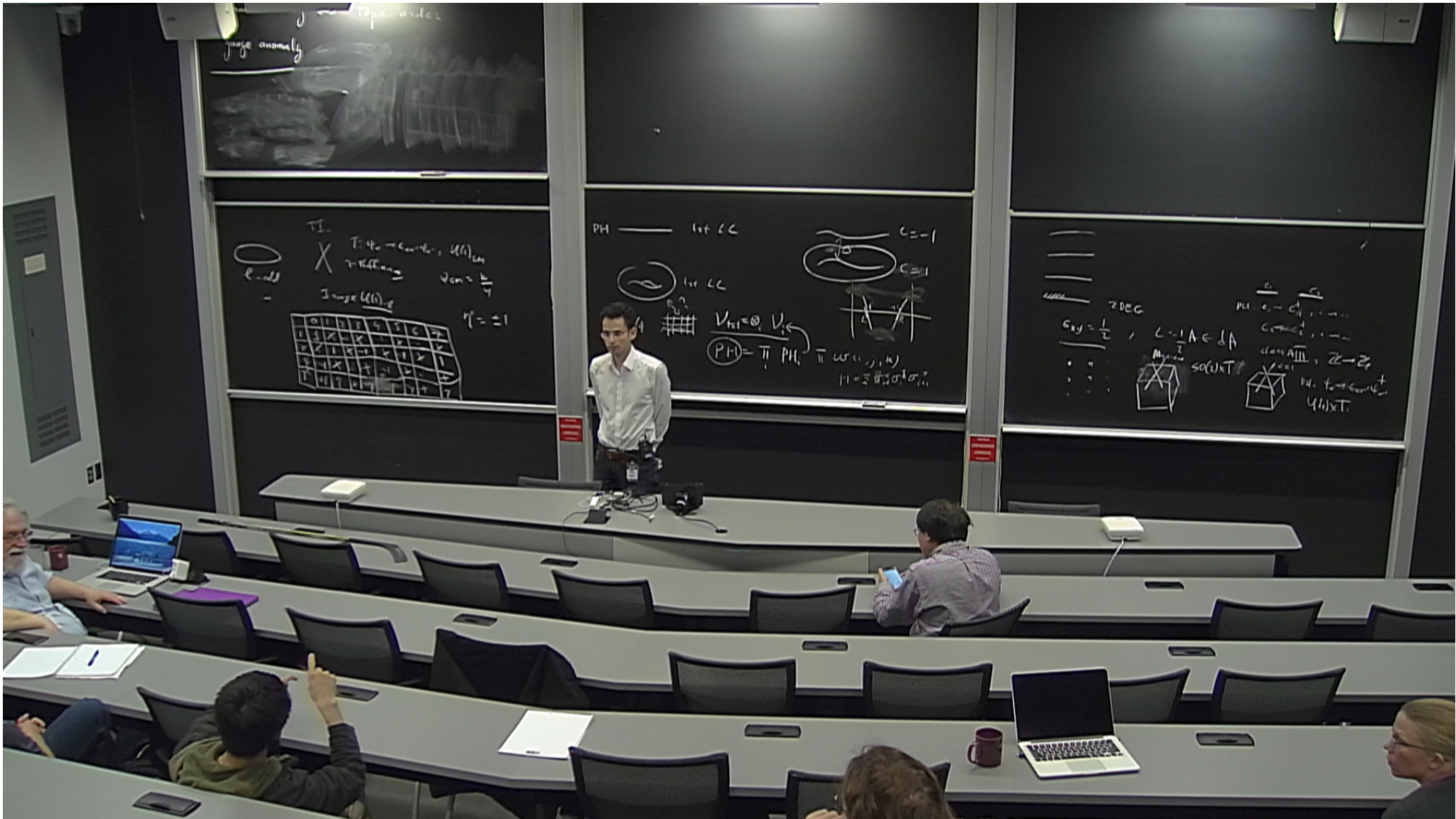
$T: \mathcal{H}_G \rightarrow \mathcal{L}_{\text{ev}}, \mathcal{H}_G, U(1)_{EM}$
 $T\text{-Pfaff. an}$

$$\psi_{EM} = \frac{k}{4}$$

$I \text{ sing } X \underline{U(1)}_8$

	0	1	2	3	4	5	6	7
1	1	X	-1	X	1	X	-1	X
σ	X	1	X	-1	X	-1	X	1
T ²	1	X	1	+	-1	+	1	+
T	+			+	-1		+	





PH _____ 1st \llcorner

$T_I + eT_{II}$

b_1
 b_3
|||
|||

SPT, bosons T , \mathbb{Z}_2^2

$T: \lambda_0 \rightarrow \lambda_1$

b_3

b_3

CAUTION
DO NOT TOUCH THE BOARD SURFACE
OR THE BOARD FRAME
OR THE BOARD MOUNTING BRACKET

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PH ————— 1st LC

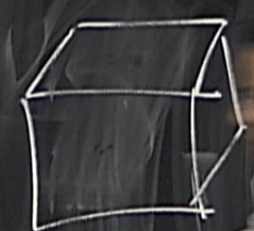
ψ
1
 ψ_3
|||
sum

$T: \lambda_1 \rightarrow \lambda_2$

$TI + eTmT$

SPT, bosons T , \mathbb{Z}_2^2

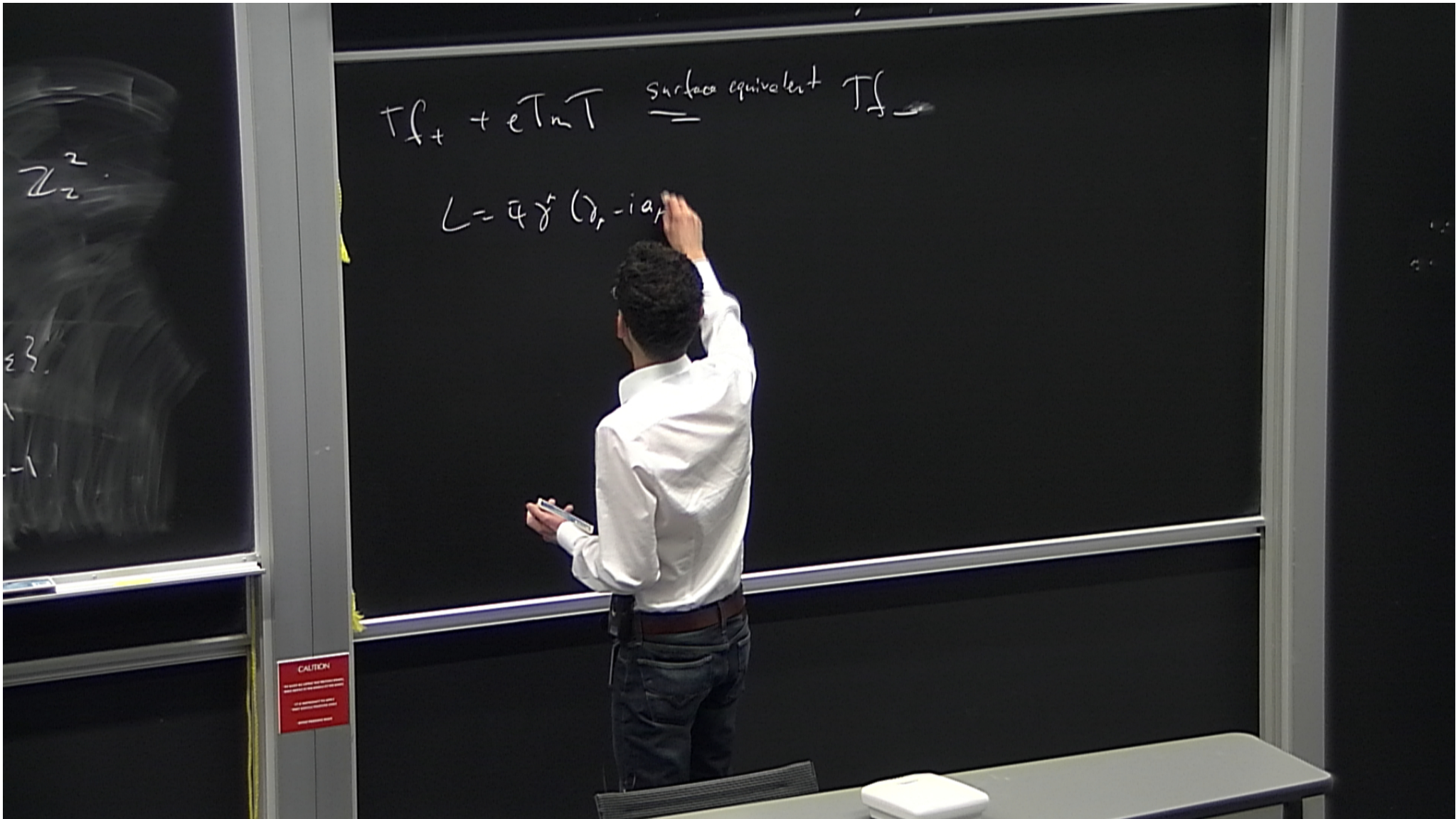
$eTmT$



$\{n, \epsilon\}$

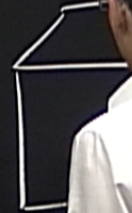
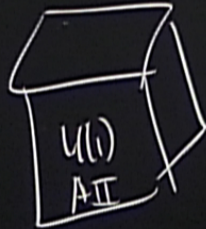
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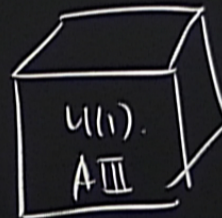
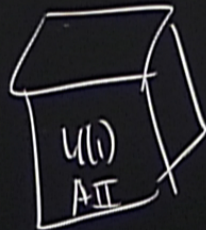
$T_{f+} + eT_{mT} \stackrel{\text{surface equivalent}}{=} T_{f-}$

$$L = 4\gamma (\gamma_r - i\alpha_r) \psi + \frac{i}{\pi} A_{\mu} \epsilon_{\mu\nu} \partial_{\alpha} \lambda$$



$T_{f+} + eT_{nT} \stackrel{\text{surface equivalent}}{=} T_{f-}$

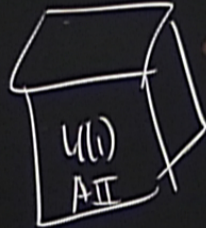
$$L = \psi^\dagger (\gamma_t - i\alpha_t) \psi + \frac{i}{4\pi} A_\mu \epsilon_{\mu\nu\lambda} \partial_\nu a_\lambda$$



CAUTION

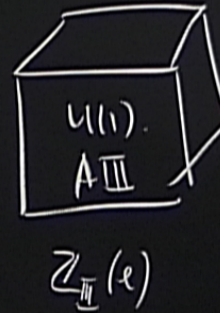
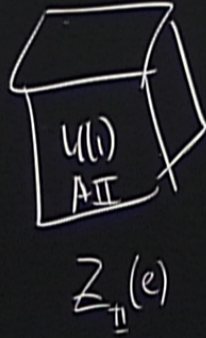
$T\psi_+ + eT\psi_- \stackrel{\text{surface equivalent}}{=} T\psi_-$

$$L = \psi^\dagger (\gamma_t - i\alpha_r) \psi + \frac{i}{4\pi} A_\mu \epsilon_{\mu\nu\lambda} \partial_\nu a_\lambda$$



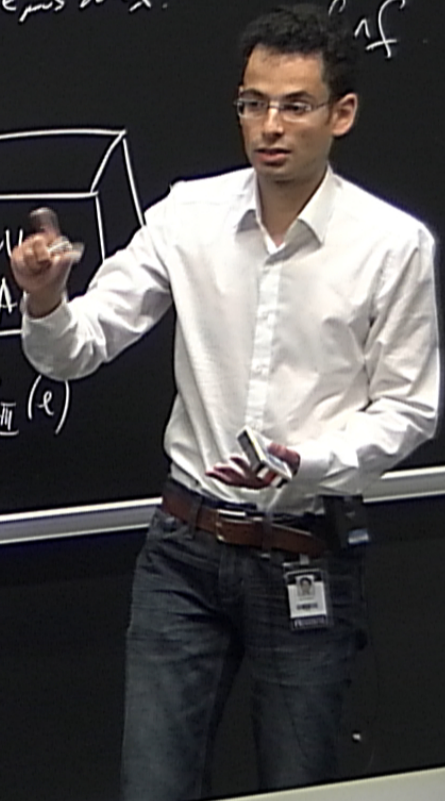
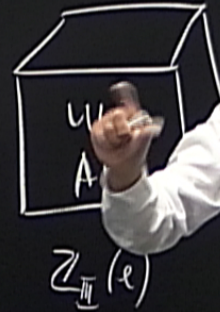
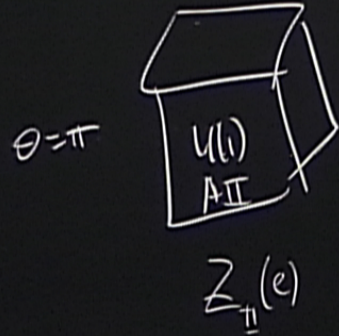
$$T_{f+} + eT_{mT} \stackrel{\text{surface equivalent}}{=} T_{f-}$$

$$L = \psi \gamma^{\mu} (\partial_{\mu} - ia_{\mu}) \psi + \frac{i}{4\pi} A_{\mu} \epsilon^{\mu\nu\sigma\lambda} \partial_{\nu} a_{\lambda}$$



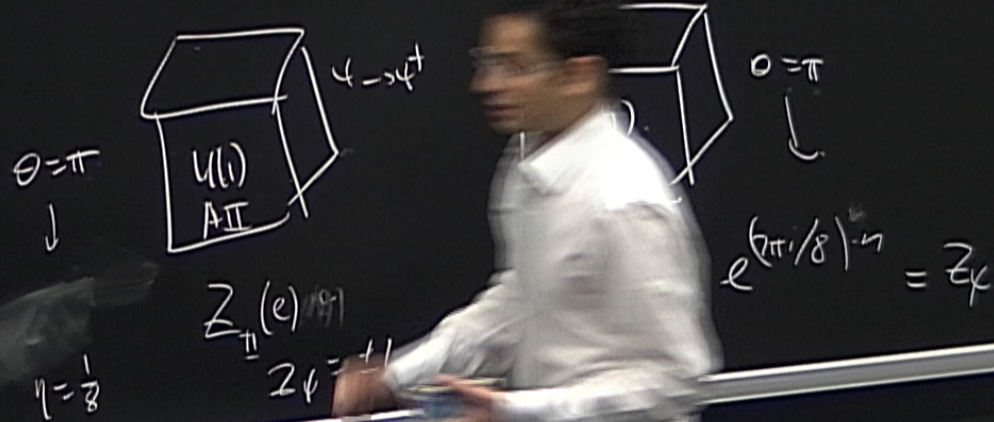
$$Tf_+ + eTmT \stackrel{\text{surface equivalent}}{=} Tf_-$$

$$L = \psi^\dagger (\gamma_t - i\alpha_t) \psi + \frac{i}{4\pi} A_\mu \epsilon_{\mu\nu\lambda} \partial_\nu a_\lambda$$



$$Tf_+ + eTmT \stackrel{\text{surface equivalent}}{=} Tf_-$$

$$L = \psi^\dagger (\gamma_r - i\alpha_r) \psi + \frac{i}{4\pi} A_\mu \epsilon_{\mu\nu\lambda} \partial_\nu a_\lambda \quad f_{nf}$$

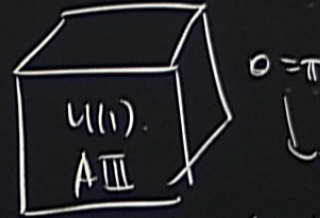
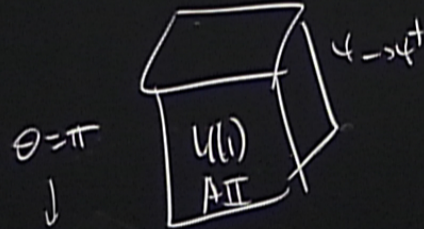


$Tf_+ + eTmT \stackrel{\text{surface equivalent}}{=} Tf_-$

$$L = \psi^\dagger (\gamma_t - i\alpha_r) \psi + \frac{i}{4\pi} A_\mu \epsilon^{\mu\nu\lambda} \partial_\nu a_\lambda$$

f_{af}

$\mathbb{Z}, \frac{\nu=1}{\nu=5} \text{CTmT.}$



$\eta = \frac{1}{8}$
 $Z_{II}(e)$
 $Z_{\psi} = \pm 1$

$Z_{II}(e), e^{(i\pi/8)\eta} = Z_{\psi}$

$\mathbb{R}P^2$

CAUTION