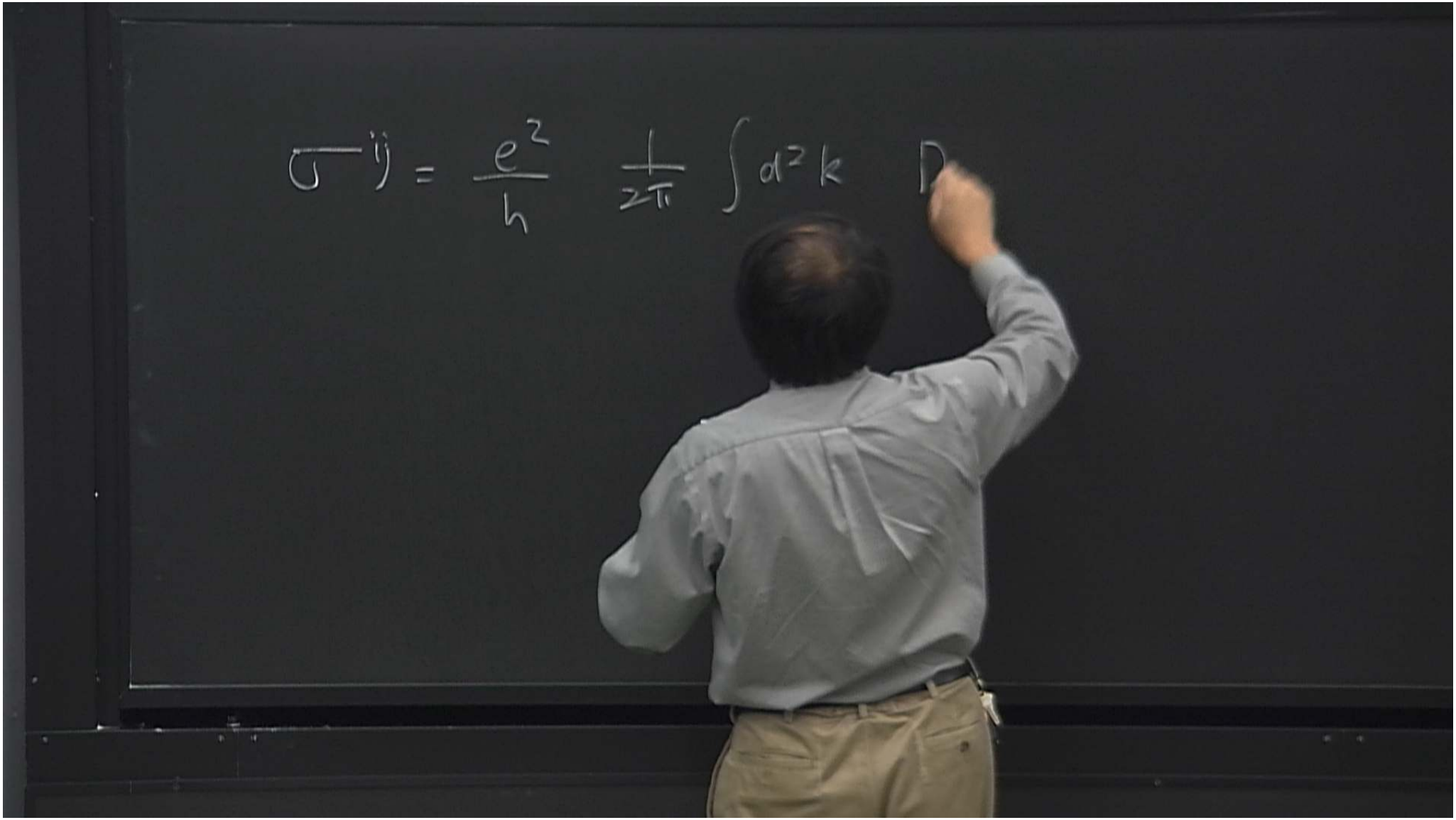
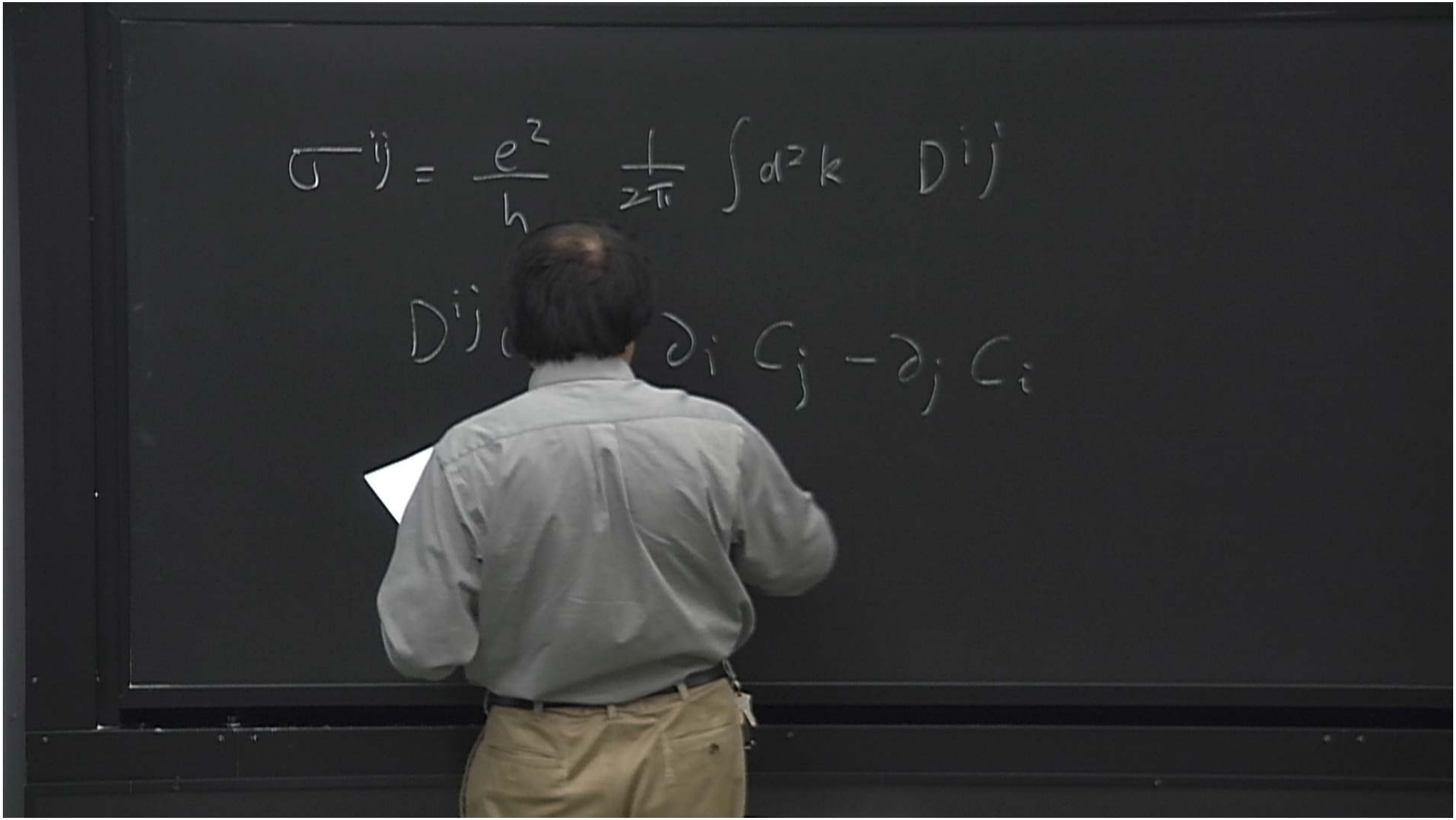
Title: 13/14 PSI - Condensed Matter - Lecture 10

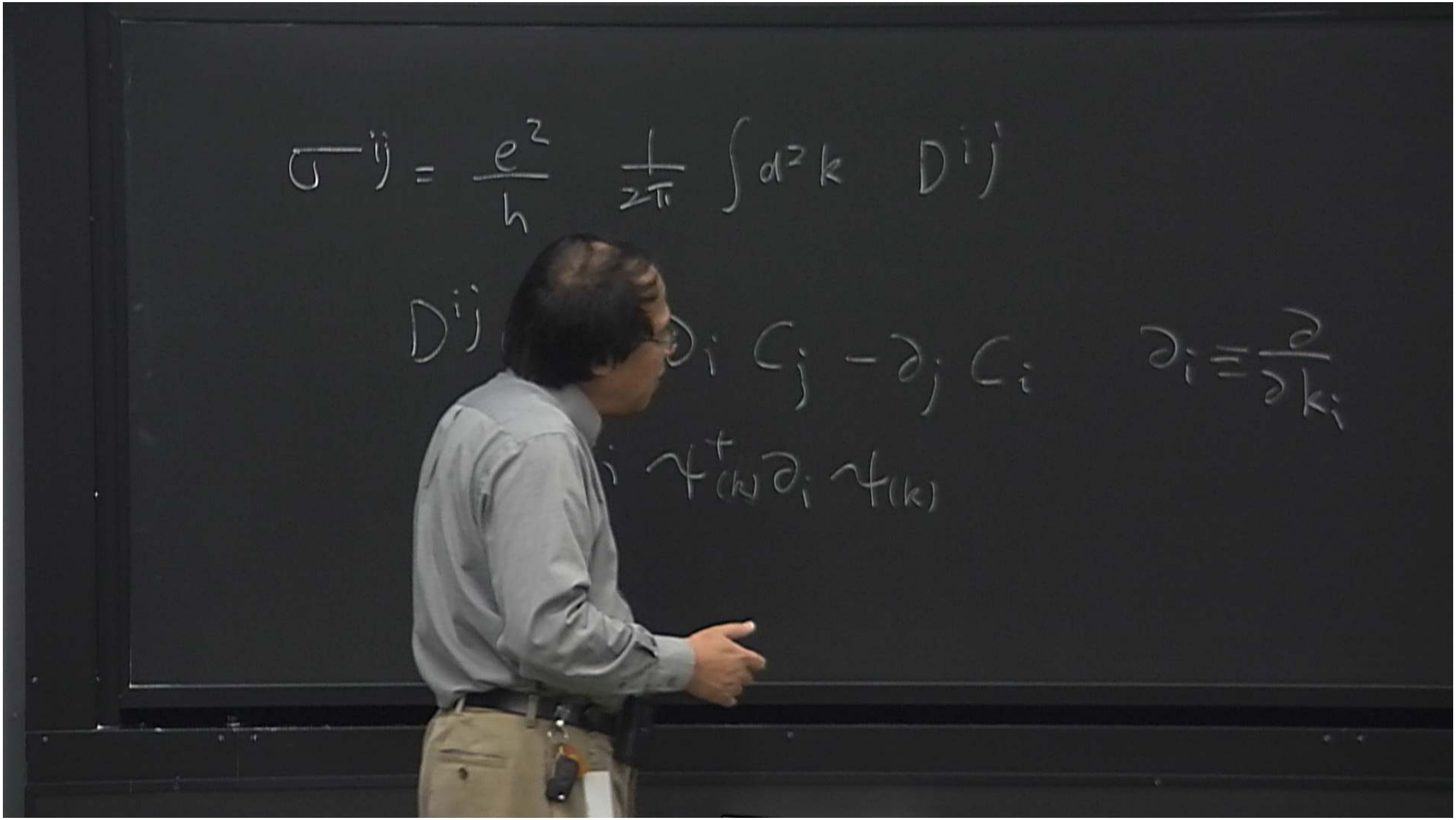
Date: Nov 22, 2013 10:45 AM

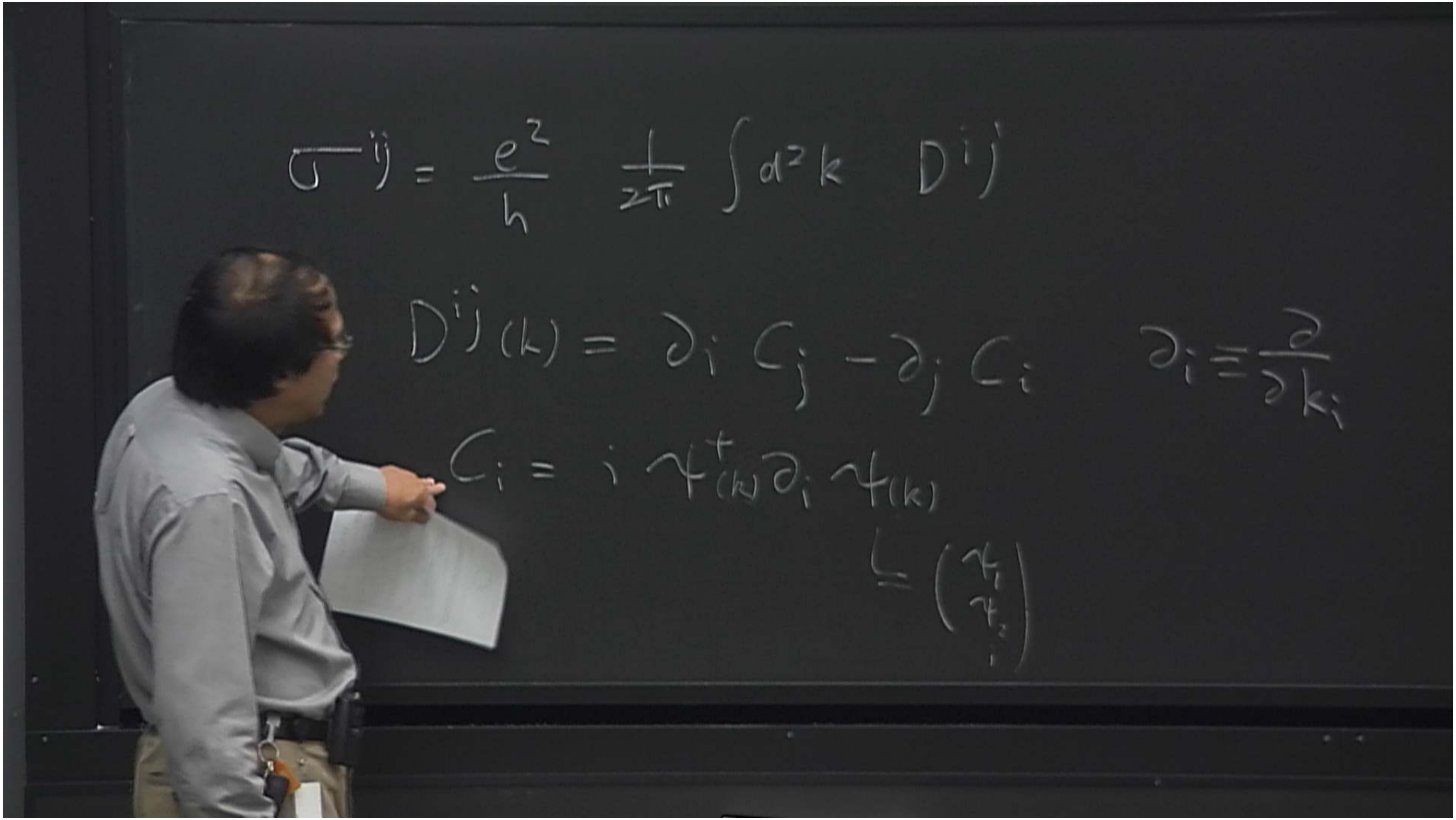
URL: http://pirsa.org/13110038

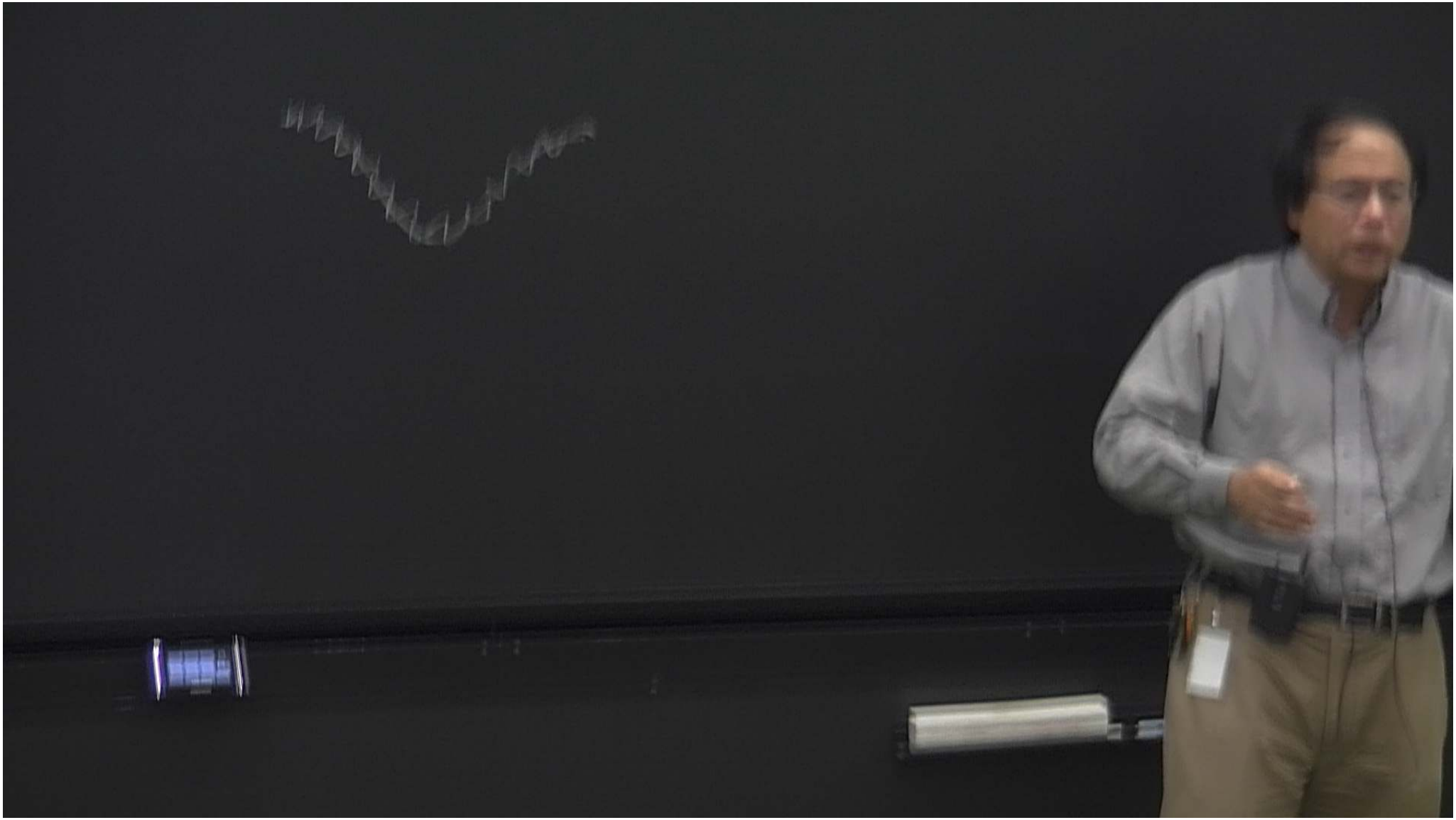
Abstract:

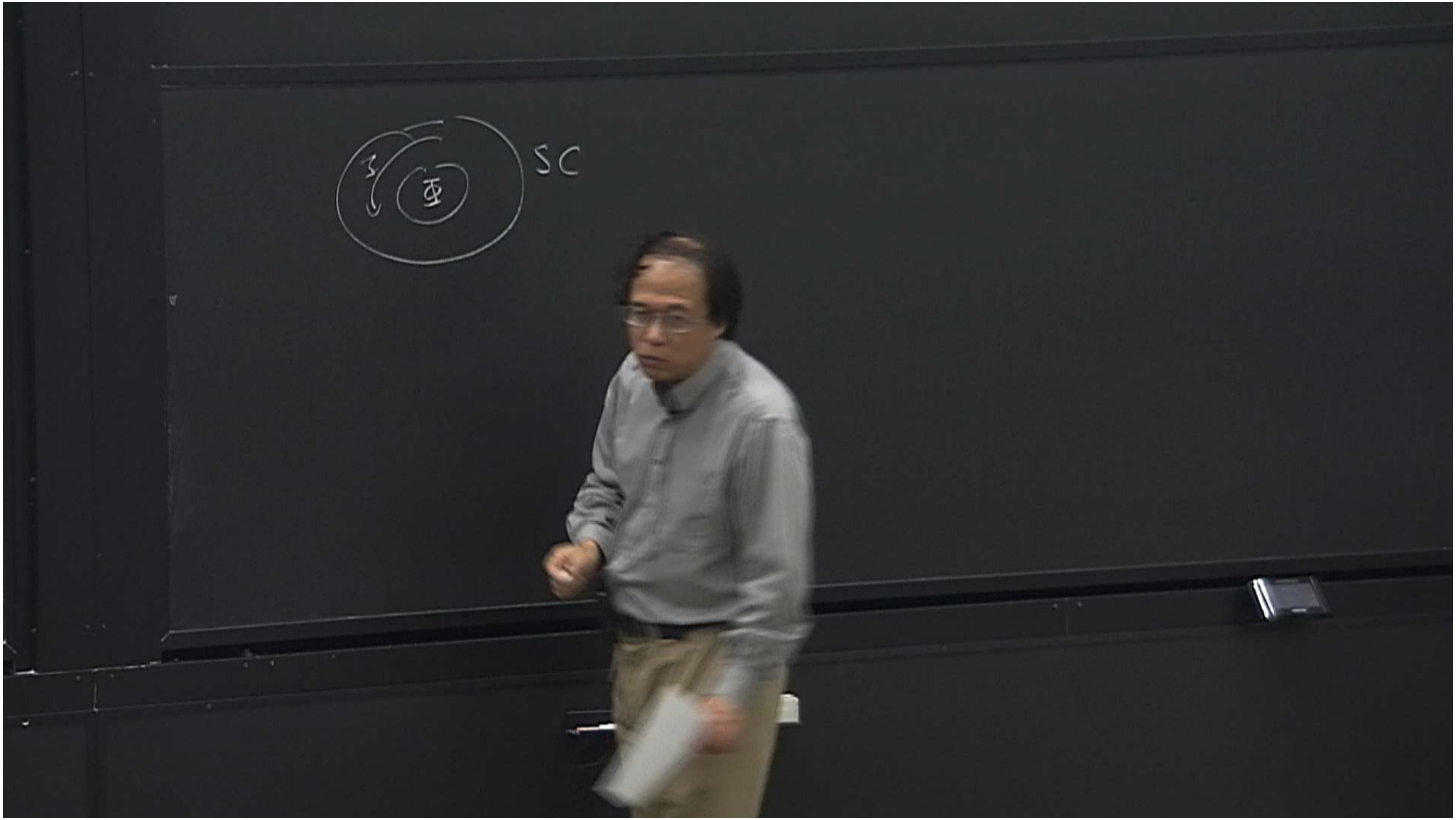

$\sigma^{ij} = \frac{e^2}{h} \frac{1}{2\pi} \int d^2k$

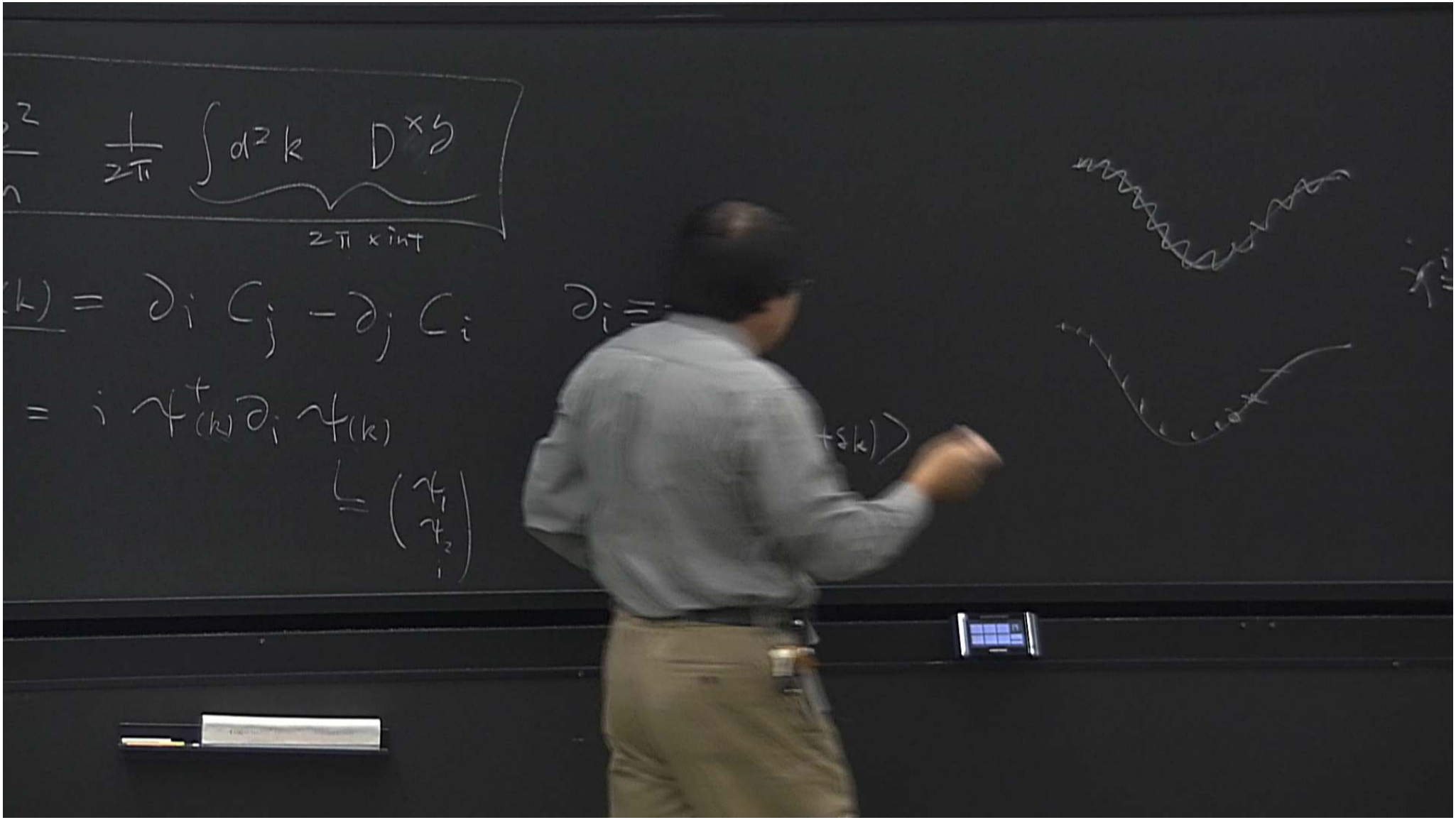

$\sigma^{ij} = \frac{e^2}{h} \frac{1}{2\pi} \int d^2k \; D^{ij}$
$D^{ij} \; \partial_i c_j - \partial_j c_i$

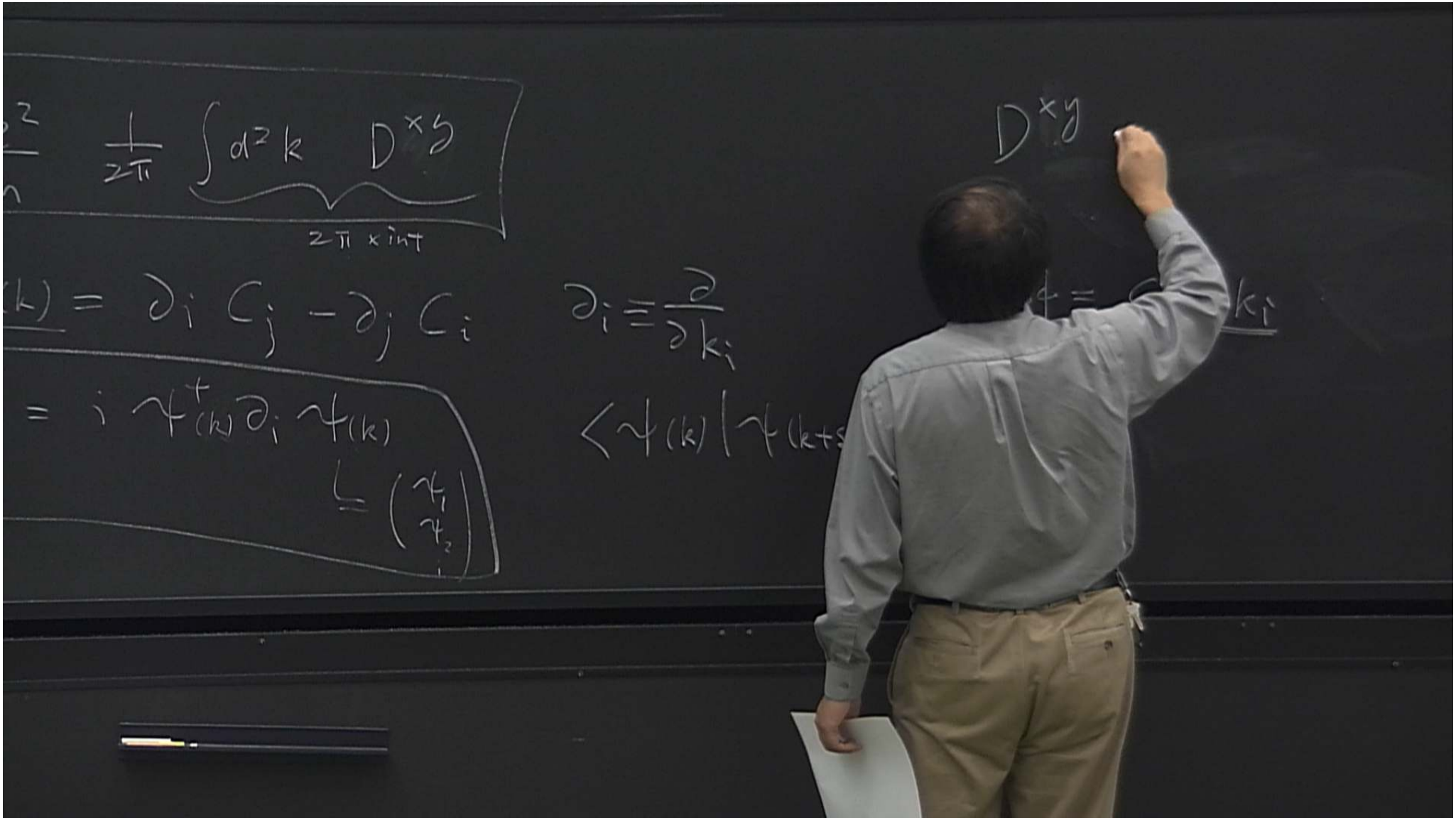

$\sigma^{ij} = \frac{e^2}{h} \frac{1}{2\pi} \int d^2k \; D^{ij}$
D^{ij}
$\partial_i c_j - \partial_j c_i$
$\partial_i \equiv \frac{\partial}{\partial k_i}$
$\eta^{\dagger}_{(k)} \partial_i \eta_{(k)}$

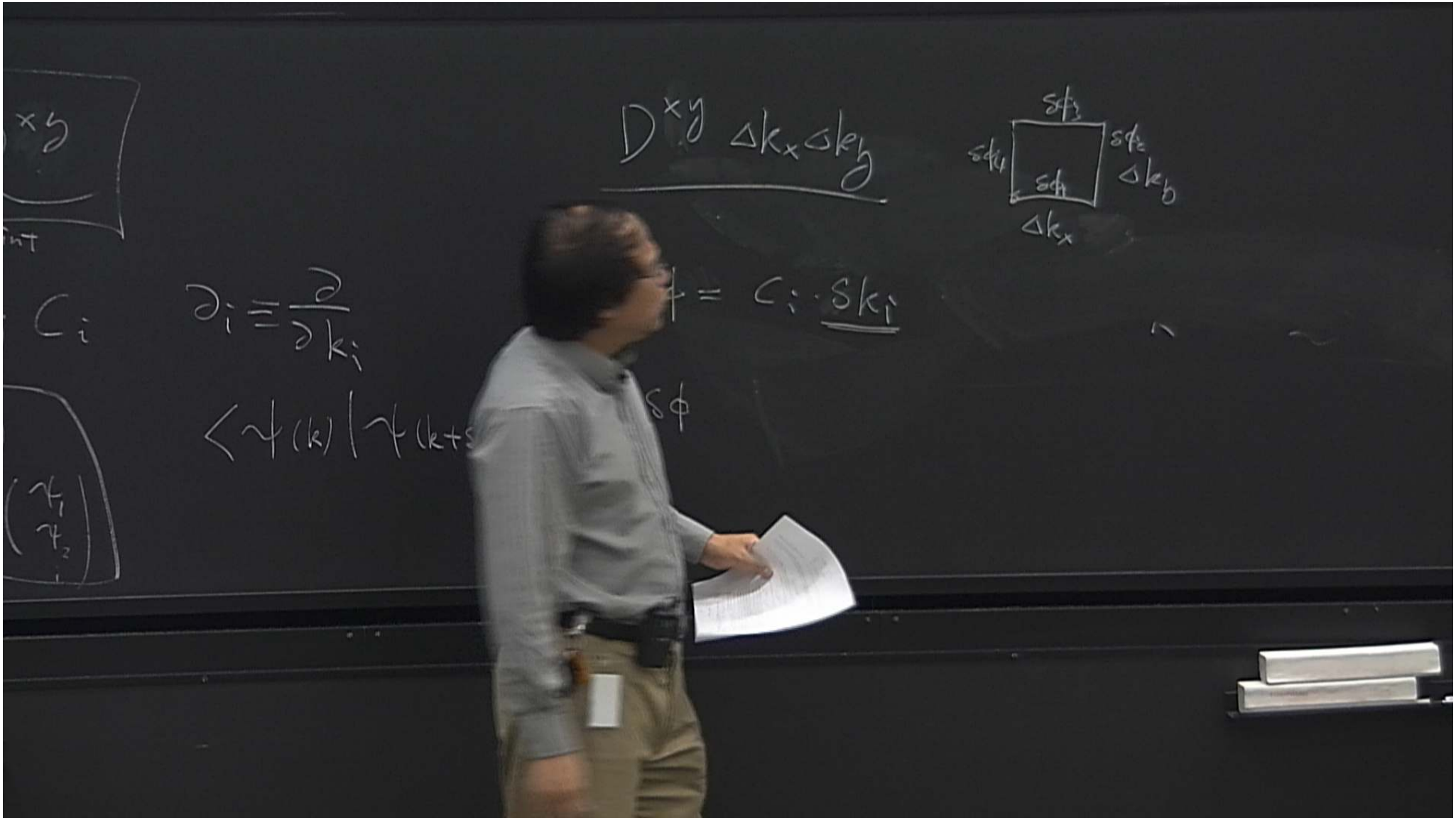

$\sigma^{ij} = \frac{e^2}{h} \frac{1}{2\pi} \int d^2k \; D^{ij}$
$D^{ij}(k) = \partial_i C_j - \partial_j C_i \qquad \partial_i \equiv \frac{\partial}{\partial k_i}$
$C_i = i \psi^\dagger(k) \partial_i \psi(k)$
$\psi = \begin{pmatrix} \psi_1 \\ \psi_2 \end{pmatrix}$

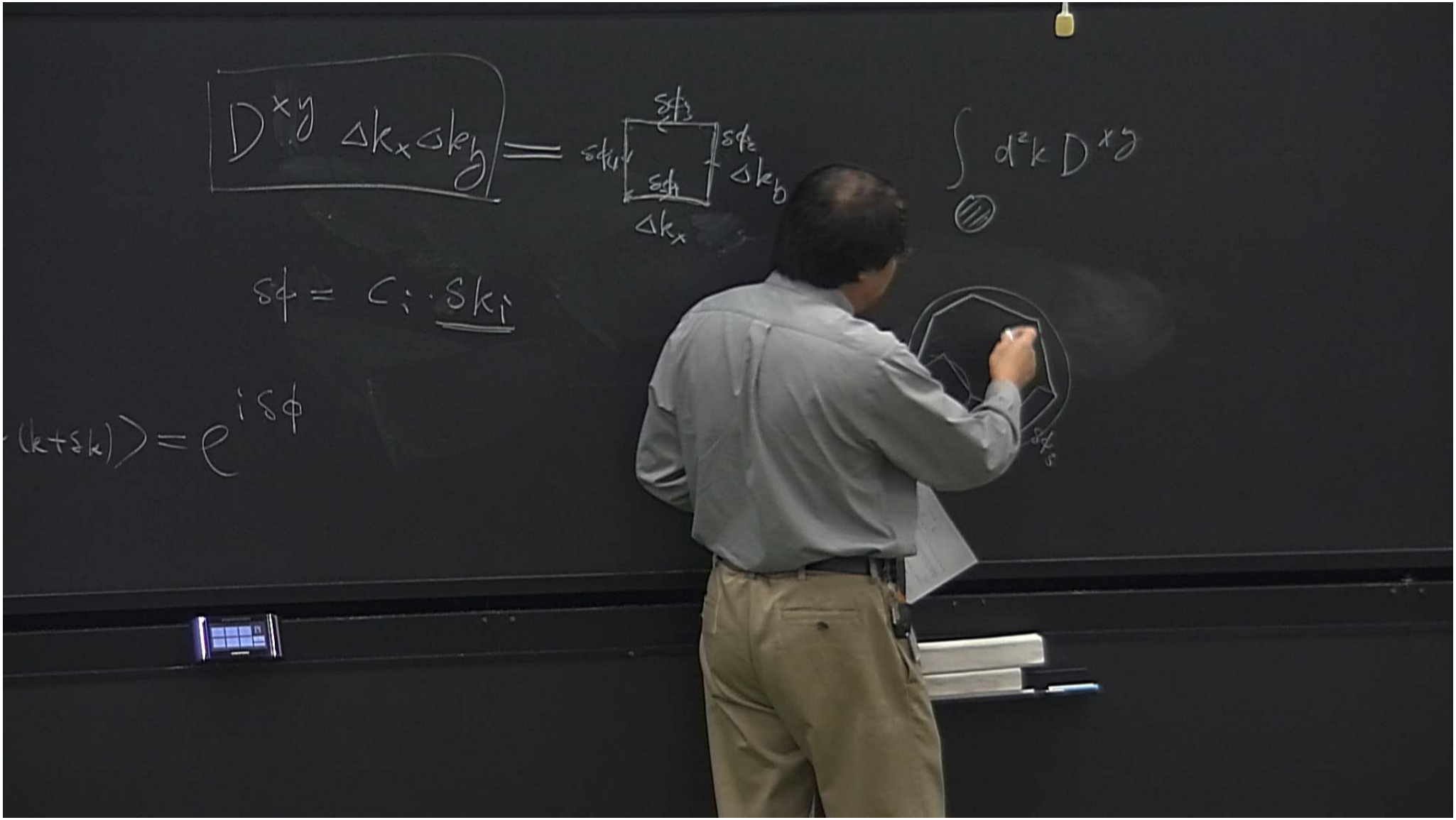


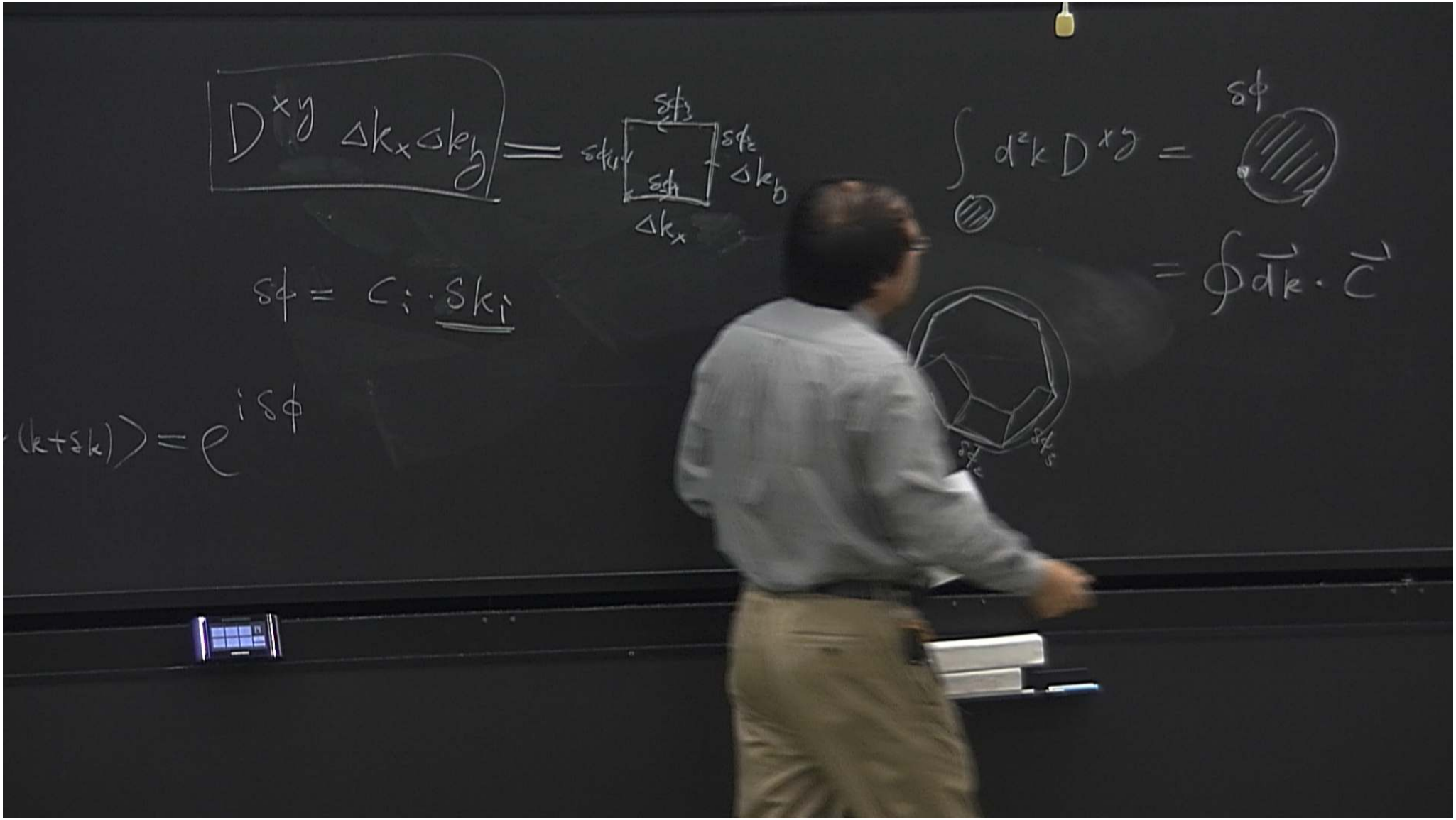

SC

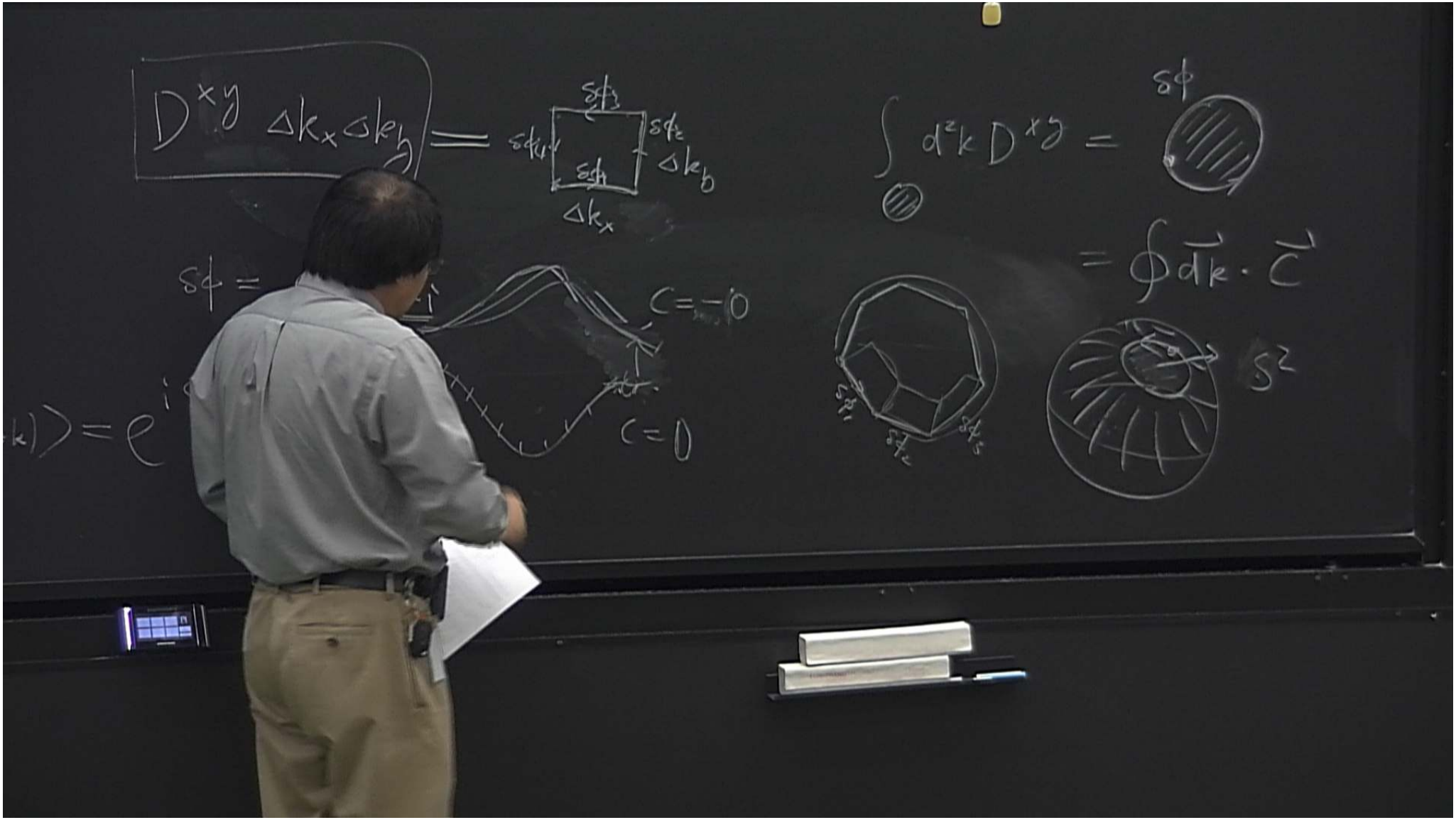

$\frac{1}{2\pi}\int d^2k \; D^{xy}$
$2\pi \times \text{int}$
$= \partial_i C_j - \partial_j C_i$
$= i\,\eta^\dagger(k)\,\partial_i\,\eta(k)$
$\eta = \begin{pmatrix} \eta_1 \\ \eta_2 \\ \vdots \end{pmatrix}$

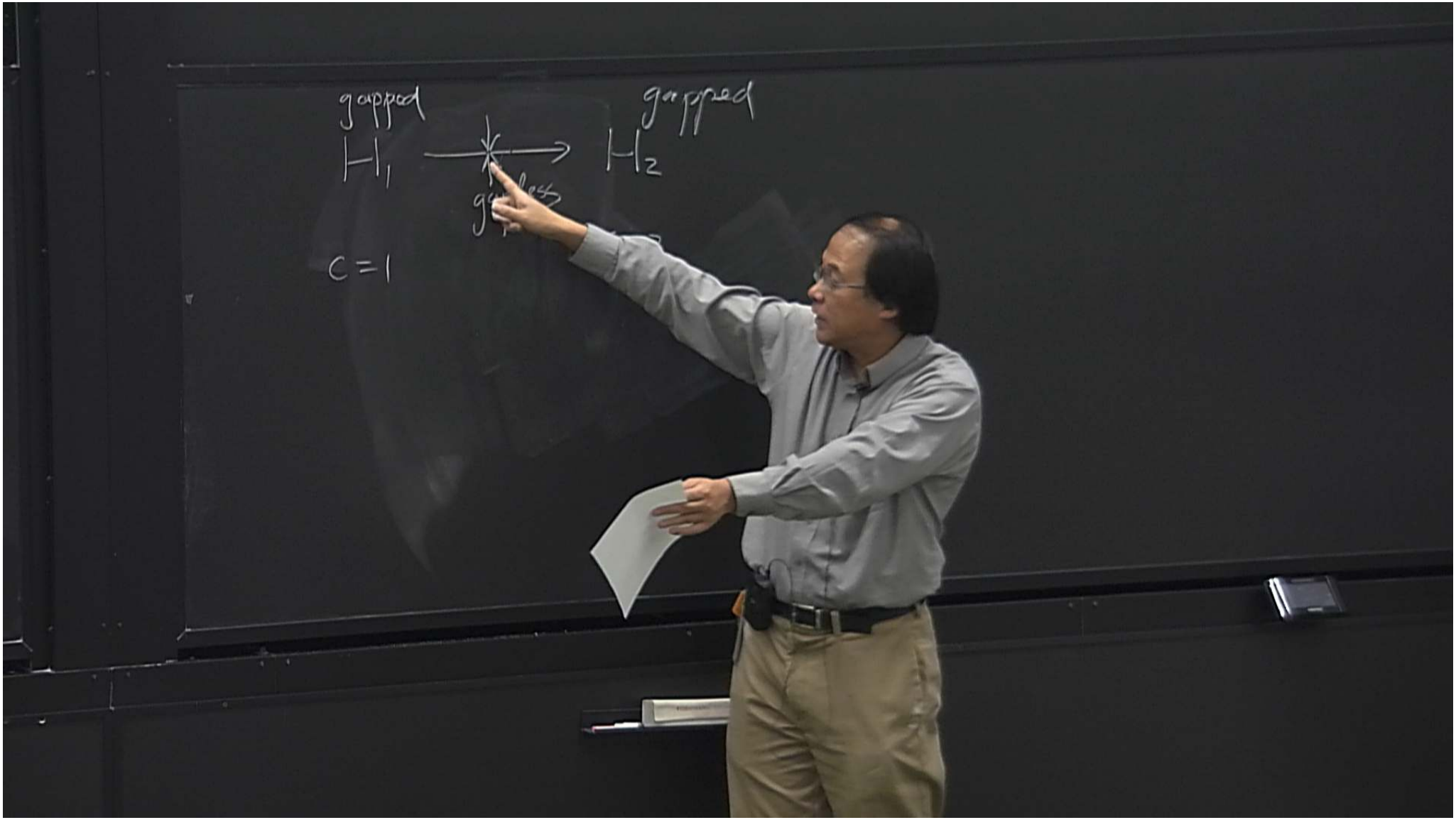

$\frac{1}{2\pi}\int d^2k \; D^{xy}$
$2\pi \times \text{int}$
D^{xy}
$= \partial_i C_j - \partial_j C_i$
$\partial_i \equiv \frac{\partial}{\partial k_i}$
$= i\psi^\dagger(k)\partial_i\psi(k)$
$\psi = \begin{pmatrix}\psi_1\\ \psi_2\end{pmatrix}$
$\langle\psi(k)|\psi(k+$

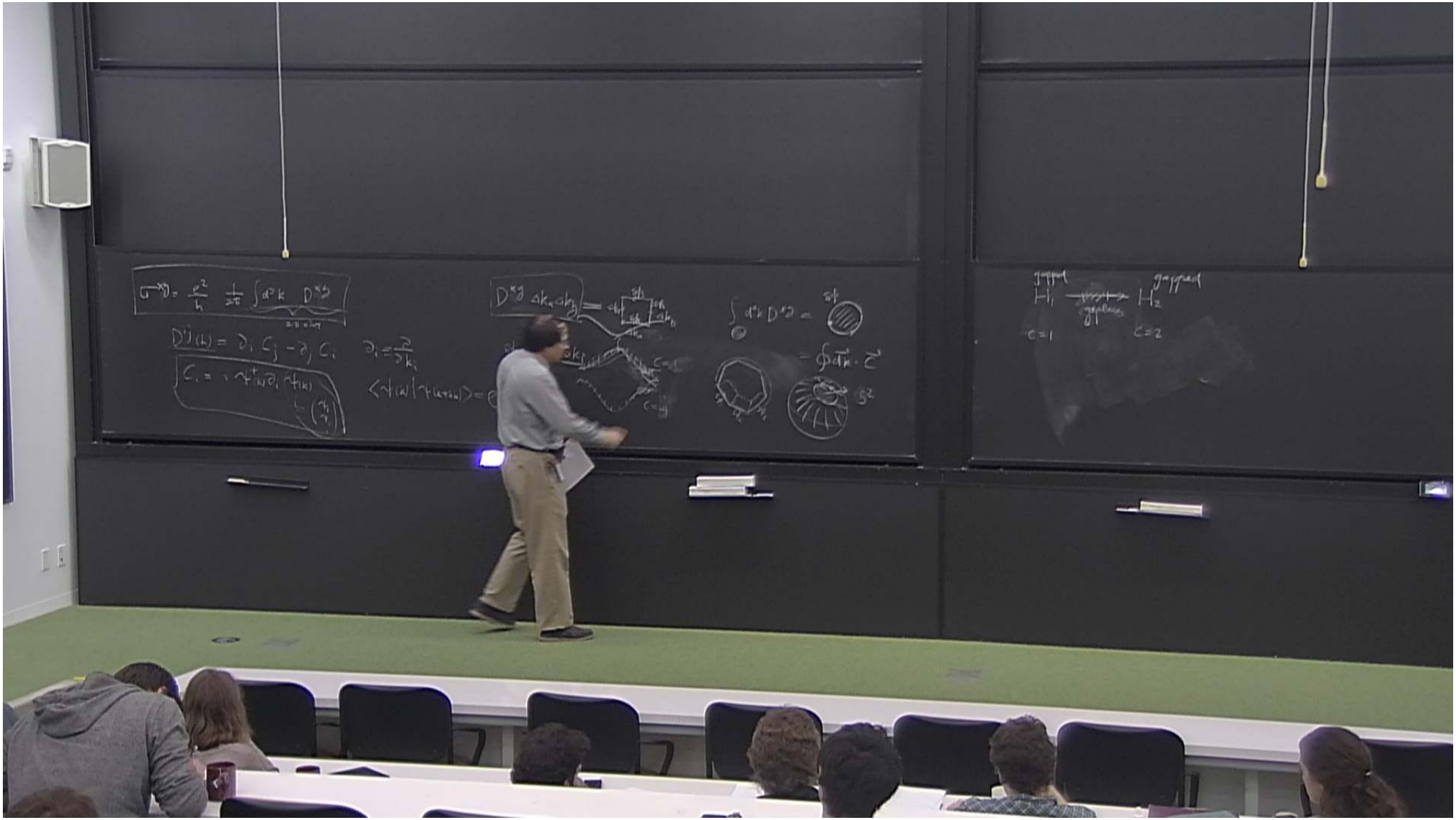

$D^{xy}\,\Delta k_x \Delta k_y$
$\partial_i \equiv \frac{\partial}{\partial k_i}$
$= c_i \cdot \delta k_i$
$\delta\phi$
Δk_x
Δk_y

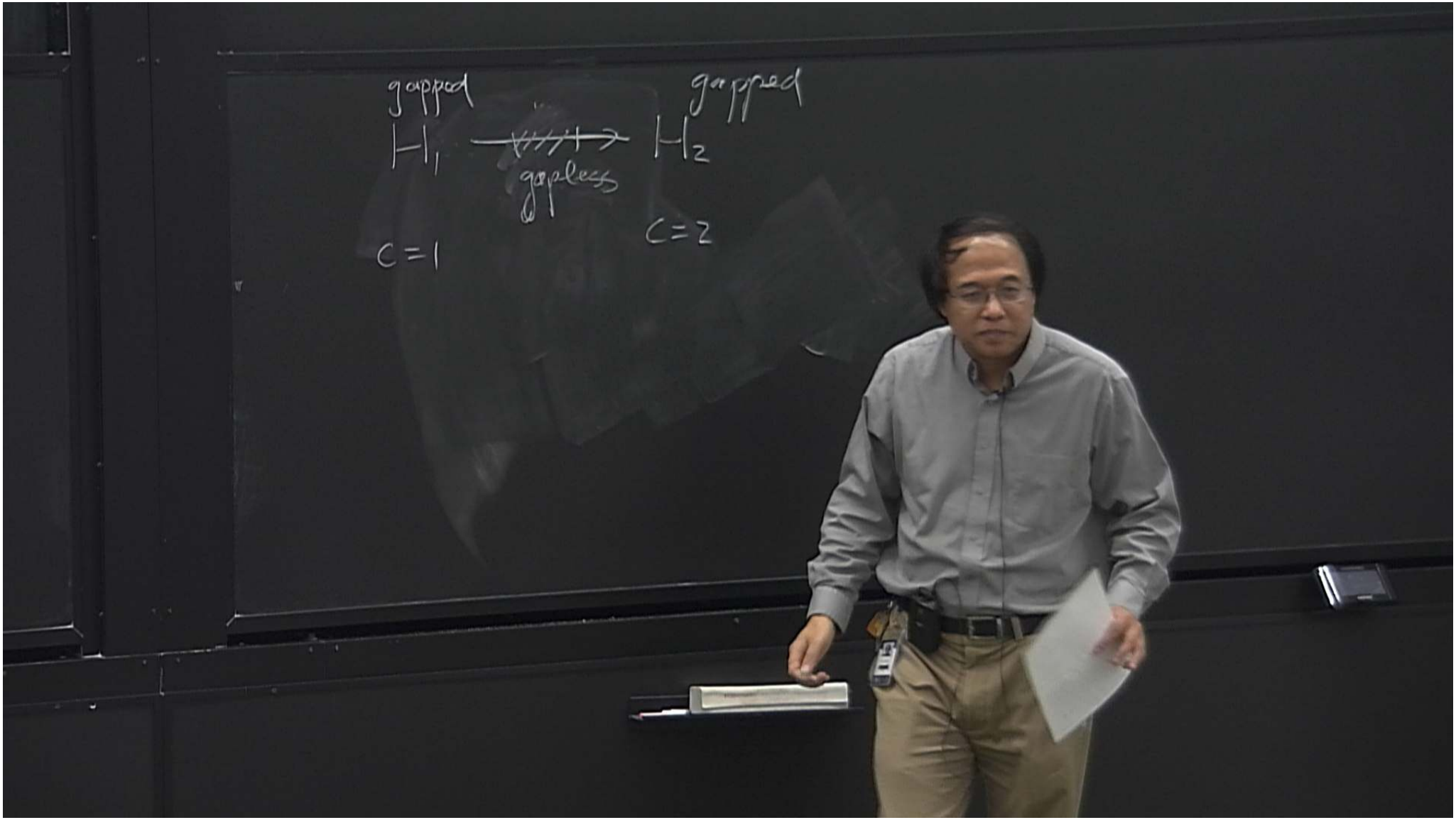

$D^{xy}\,\Delta k_x \Delta k_y =$
$\delta\phi_3$
$\delta\phi_4$
$\delta\phi_2$
$\delta\phi_1$
$\delta\phi_5$
Δk_y
Δk_x
$\int d^2k\, D^{xy}$
$\delta\phi = c_i \cdot \delta k_i$
$(k+\delta k)\rangle = e^{i\delta\phi}$
δk_5

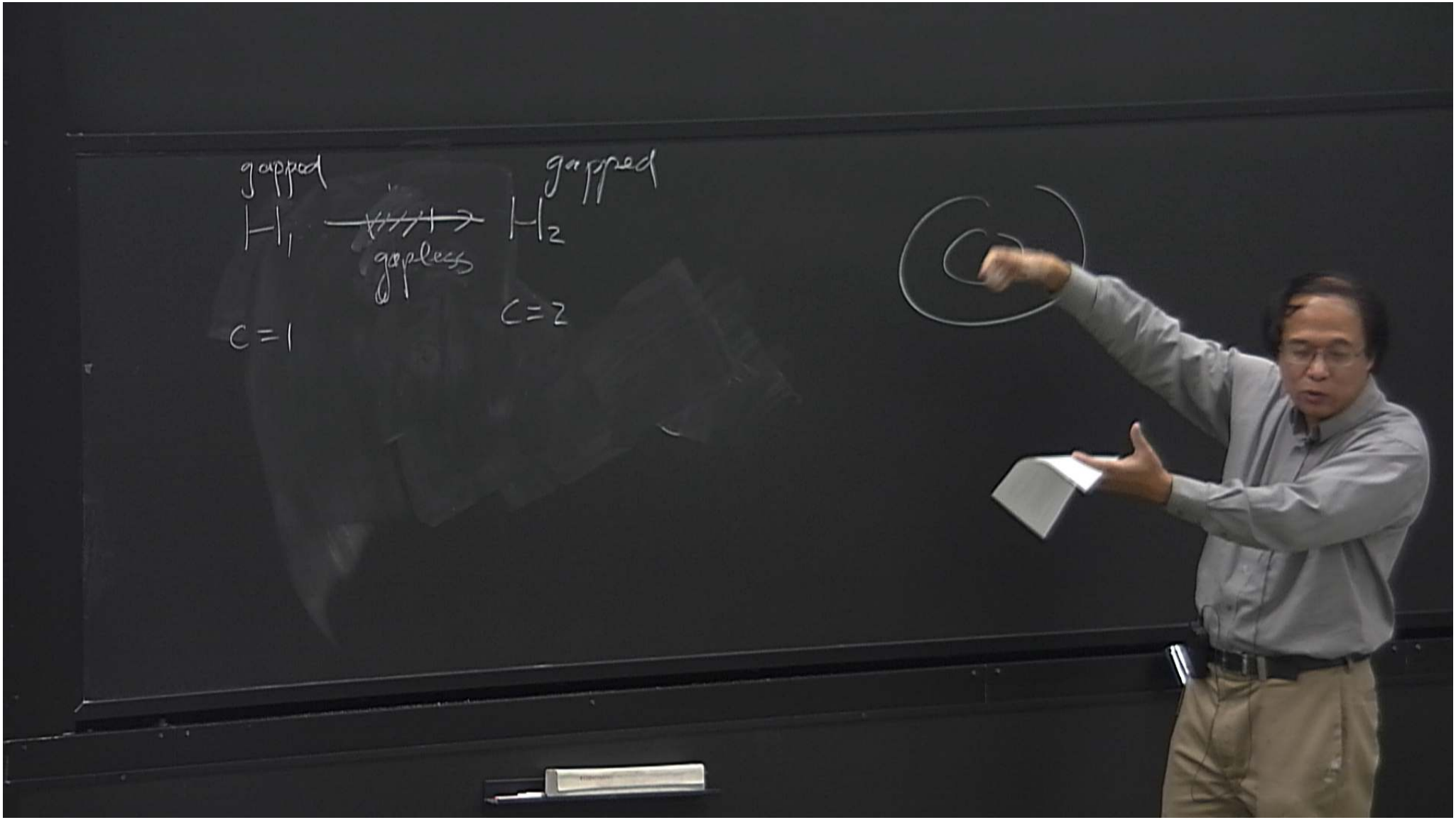

$D^{xy}\,\Delta k_x \Delta k_y =$
$\delta\phi = c_i \cdot \delta k_i$
$\int d^2k\, D^{xy} =$
$= \oint \vec{dk} \cdot \vec{c}$
$\delta\phi$
Δk_x
Δk_y

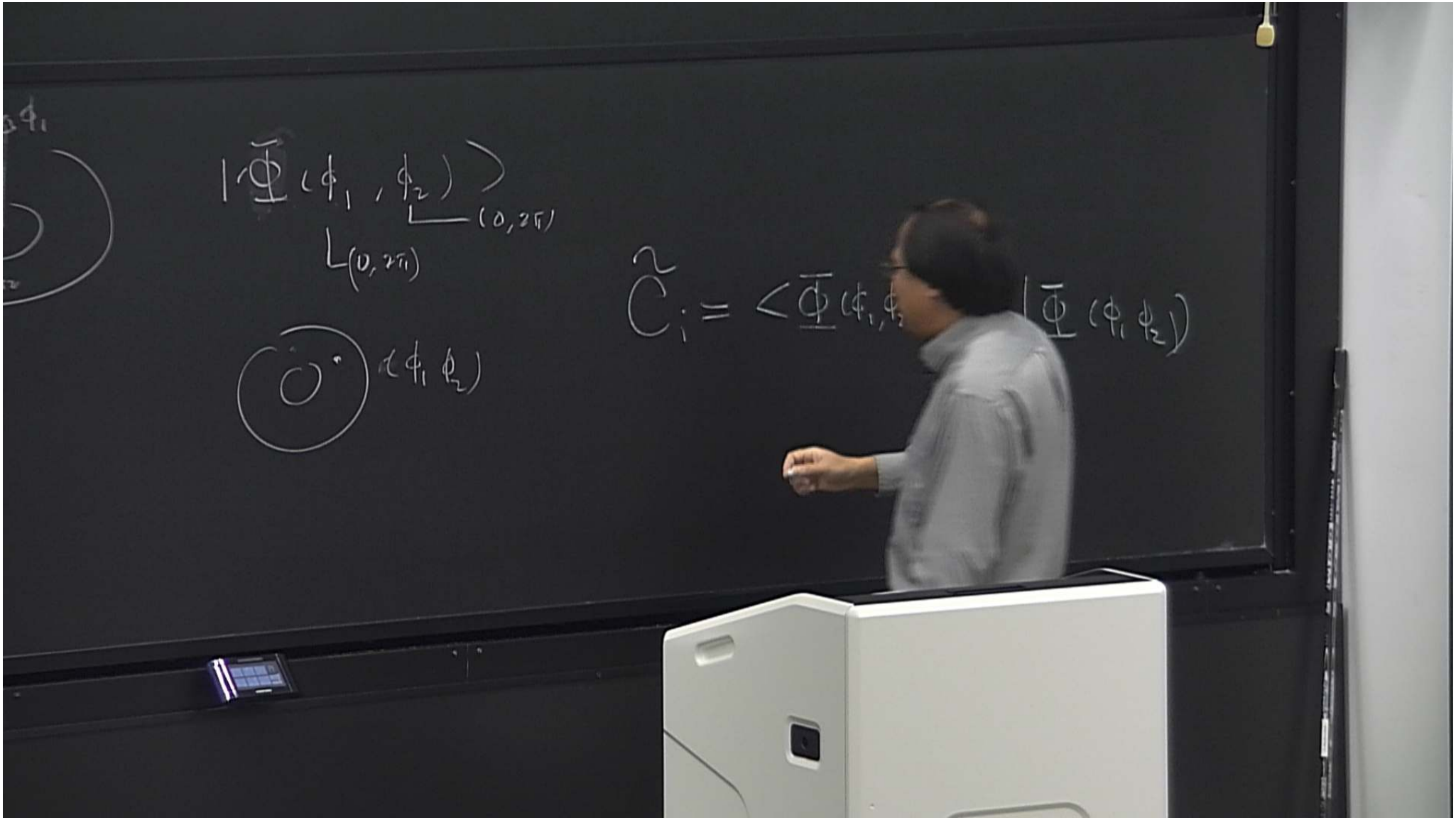

$D^{xy}\,\Delta k_x \Delta k_y =$
Δk_x
Δk_y
$\int d^2k\, D^{xy} =$
$= \oint \vec{dk} \cdot \vec{C}$
$C = -1$
$C = 1$
S^2

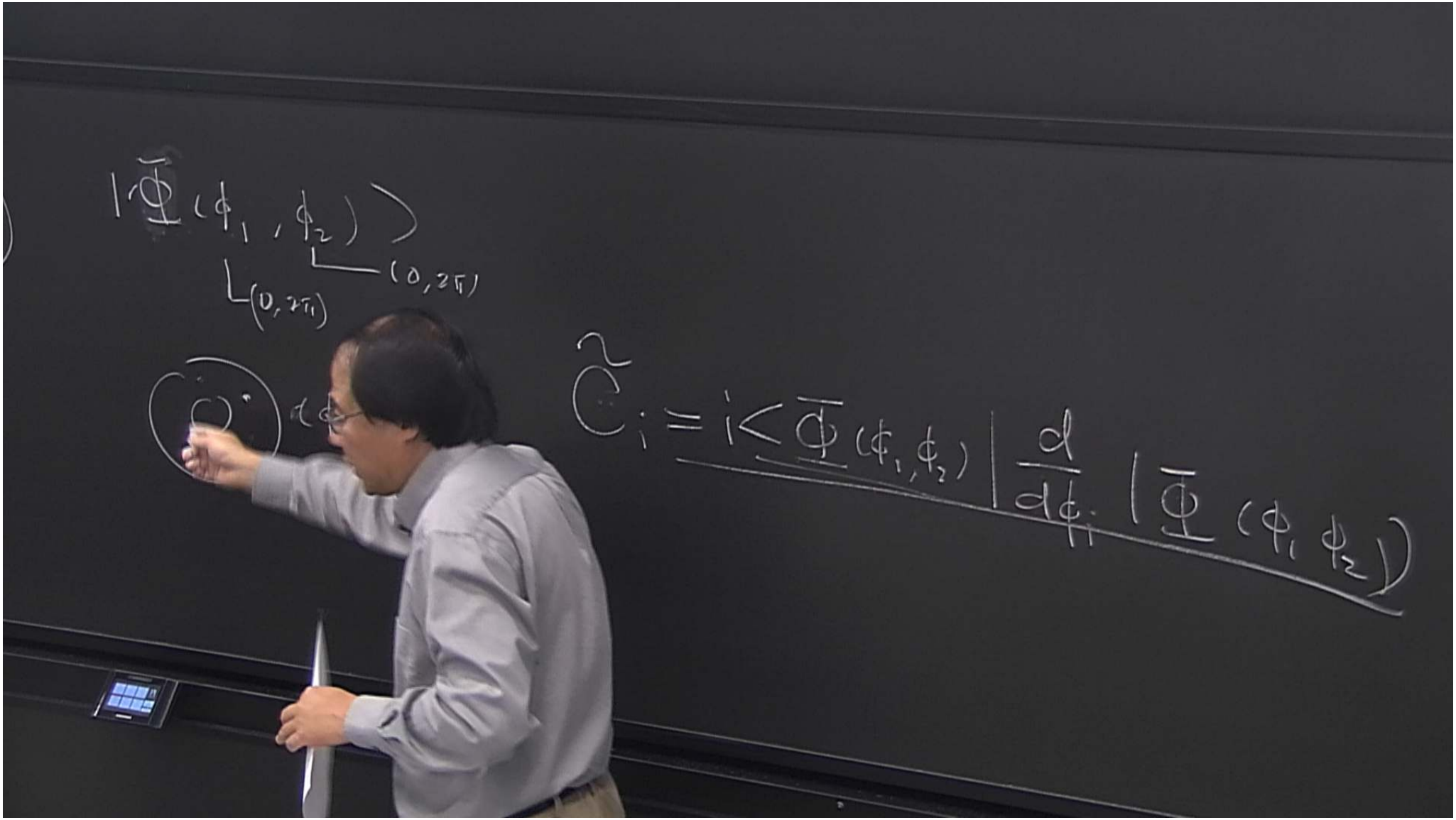

gapped
gapped
H_1
H_2
c = 1

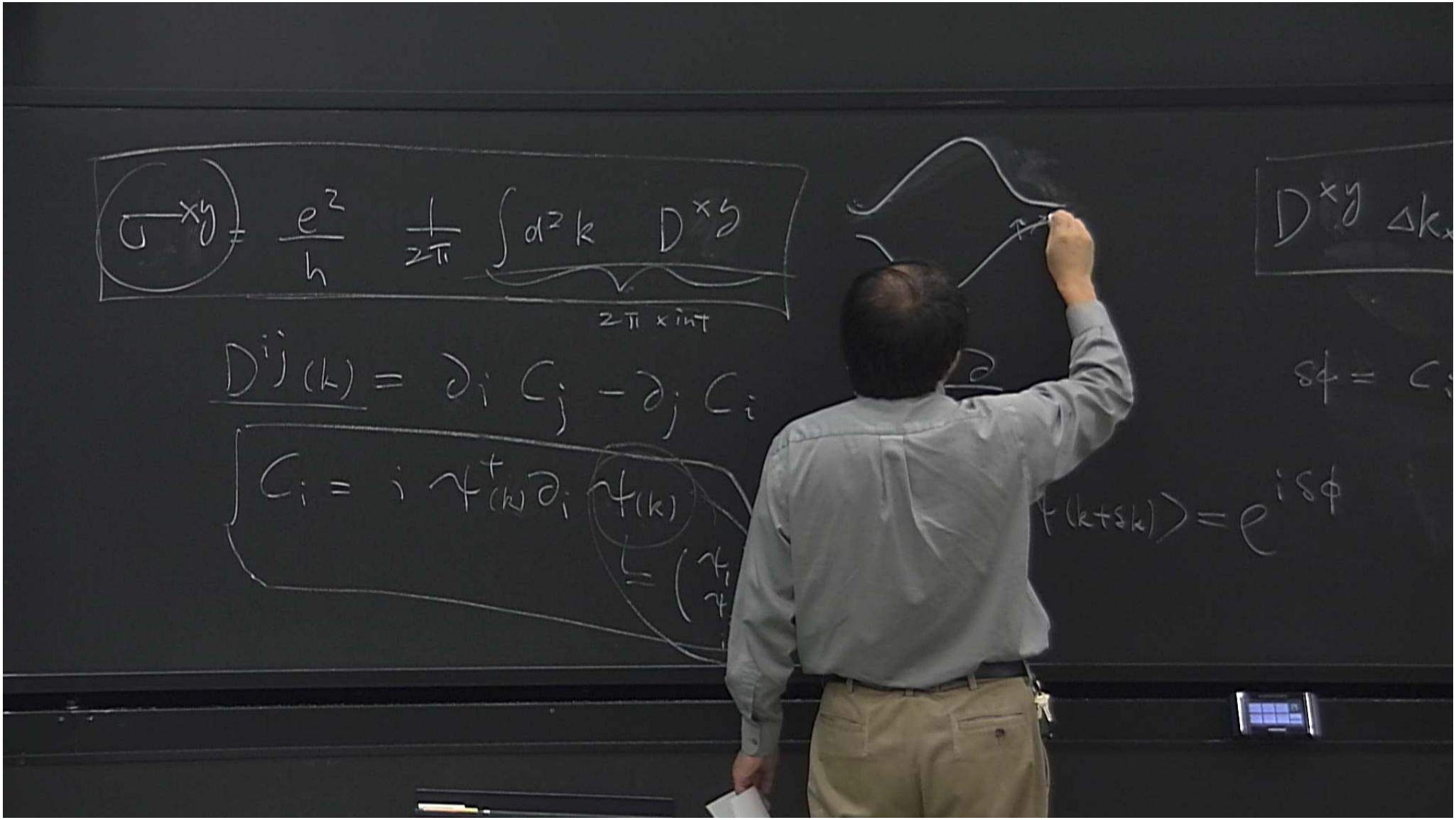


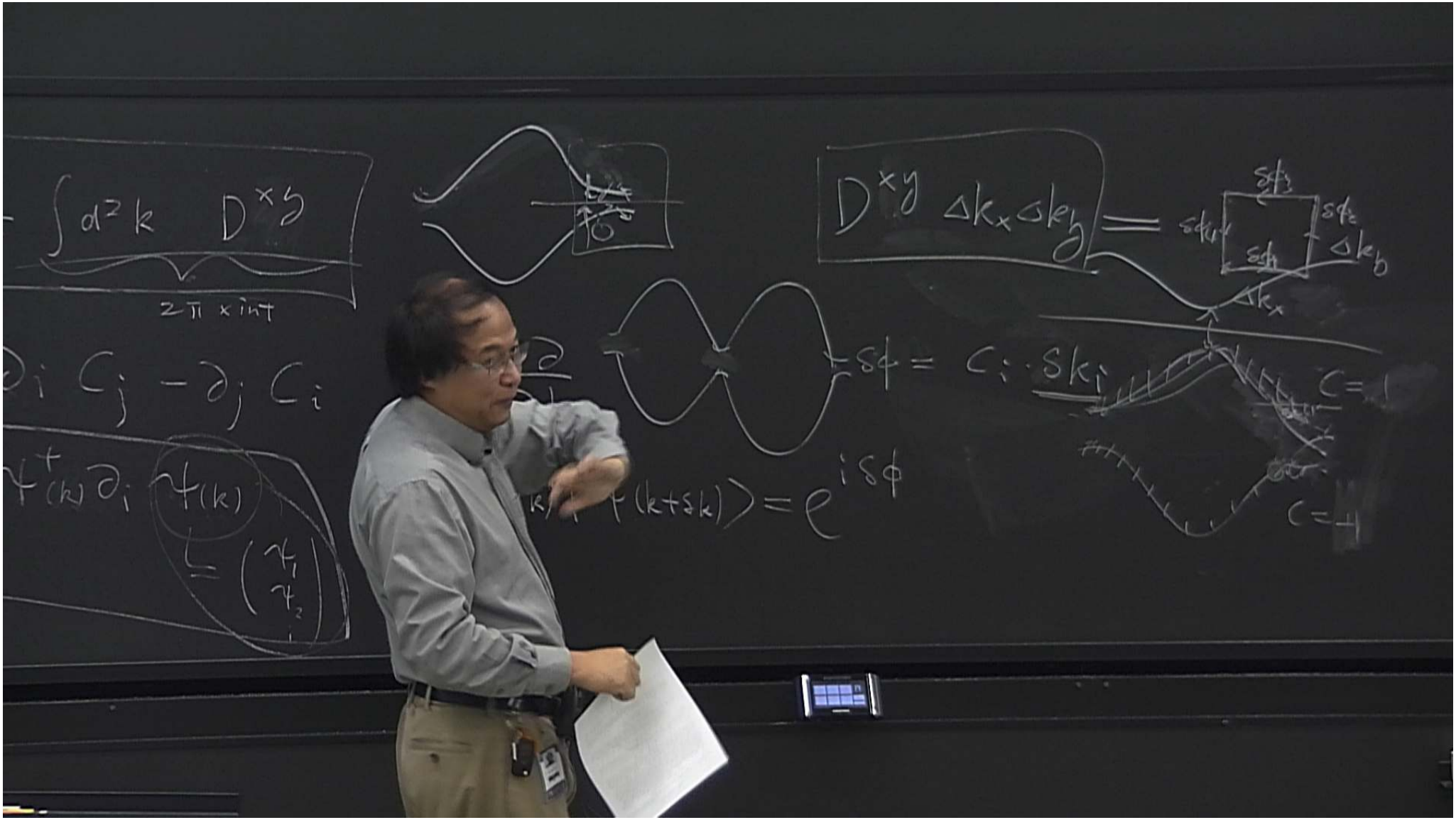

gapped
gapped
H_1
H_2
gapless
$C=1$
$C=2$


gapped
gapped
H_1
H_2
gapless
$C=1$
$C=2$

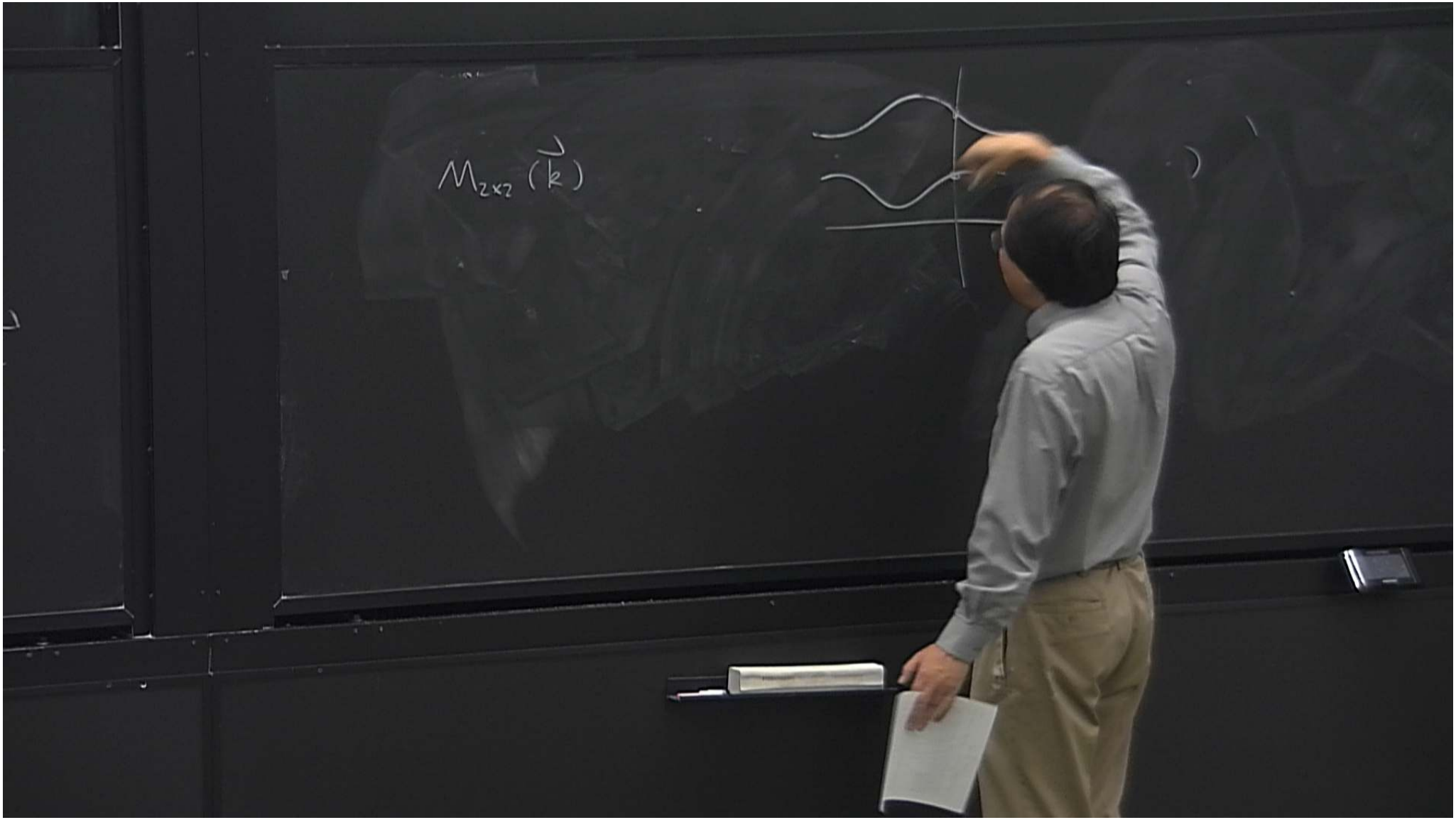

$|\bar{\Phi}(\phi_1, \phi_2)\rangle$
$(0, 2\pi)$
$(0, 2\pi)$
(ϕ_1, ϕ_2)
$\tilde{C}_i = \langle \bar{\Phi}(\phi_1, \phi_2$
$|\bar{\Phi}(\phi_1, \phi_2)\rangle$

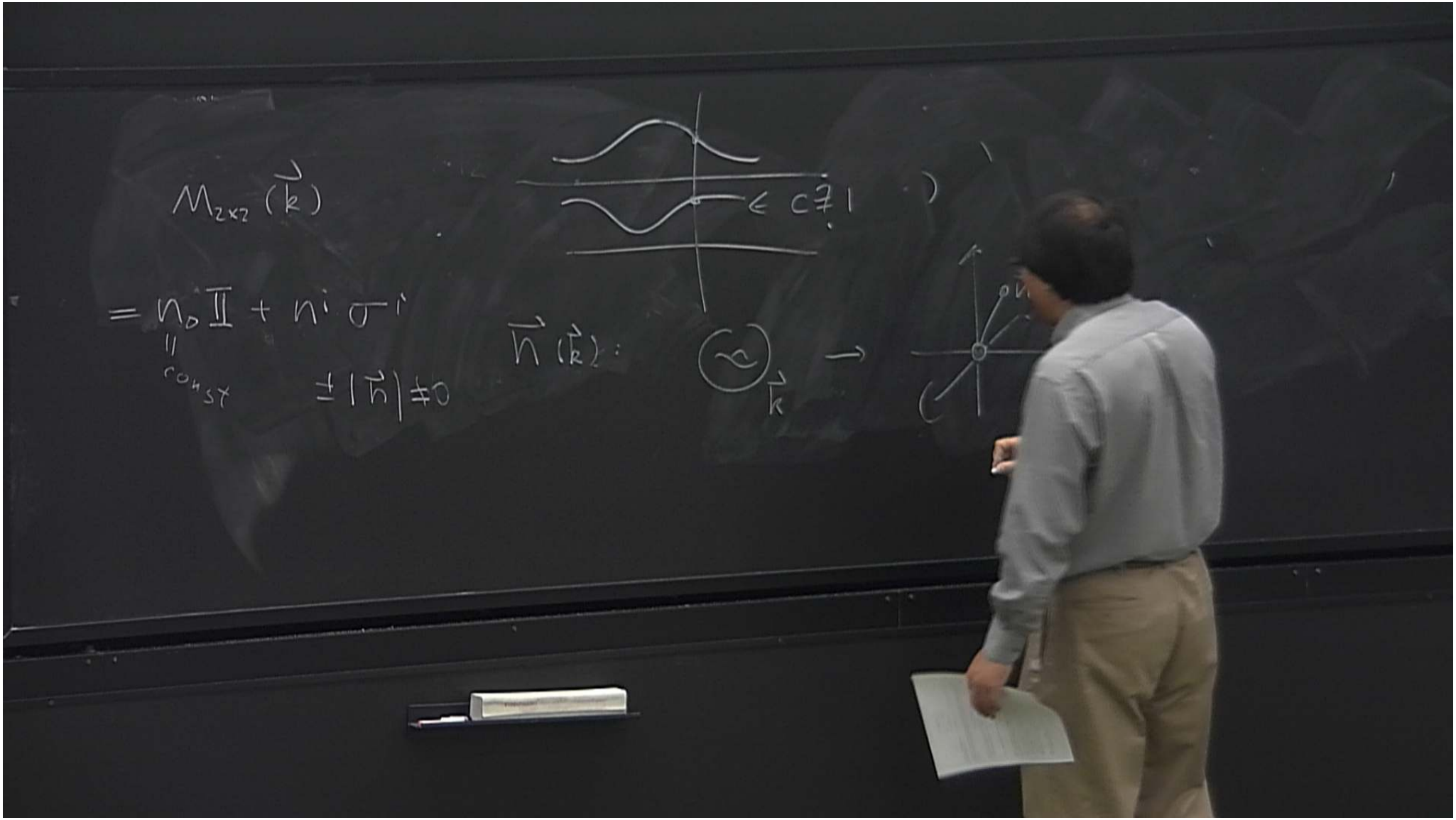

$|\Phi(\phi_1, \phi_2)\rangle$
$(0, 2\pi)$
$(0, 2\pi)$
$\tilde{C}_i = i\langle\Phi(\phi_1, \phi_2)| \frac{d}{d\phi_i} |\Phi(\phi_1, \phi_2)\rangle$

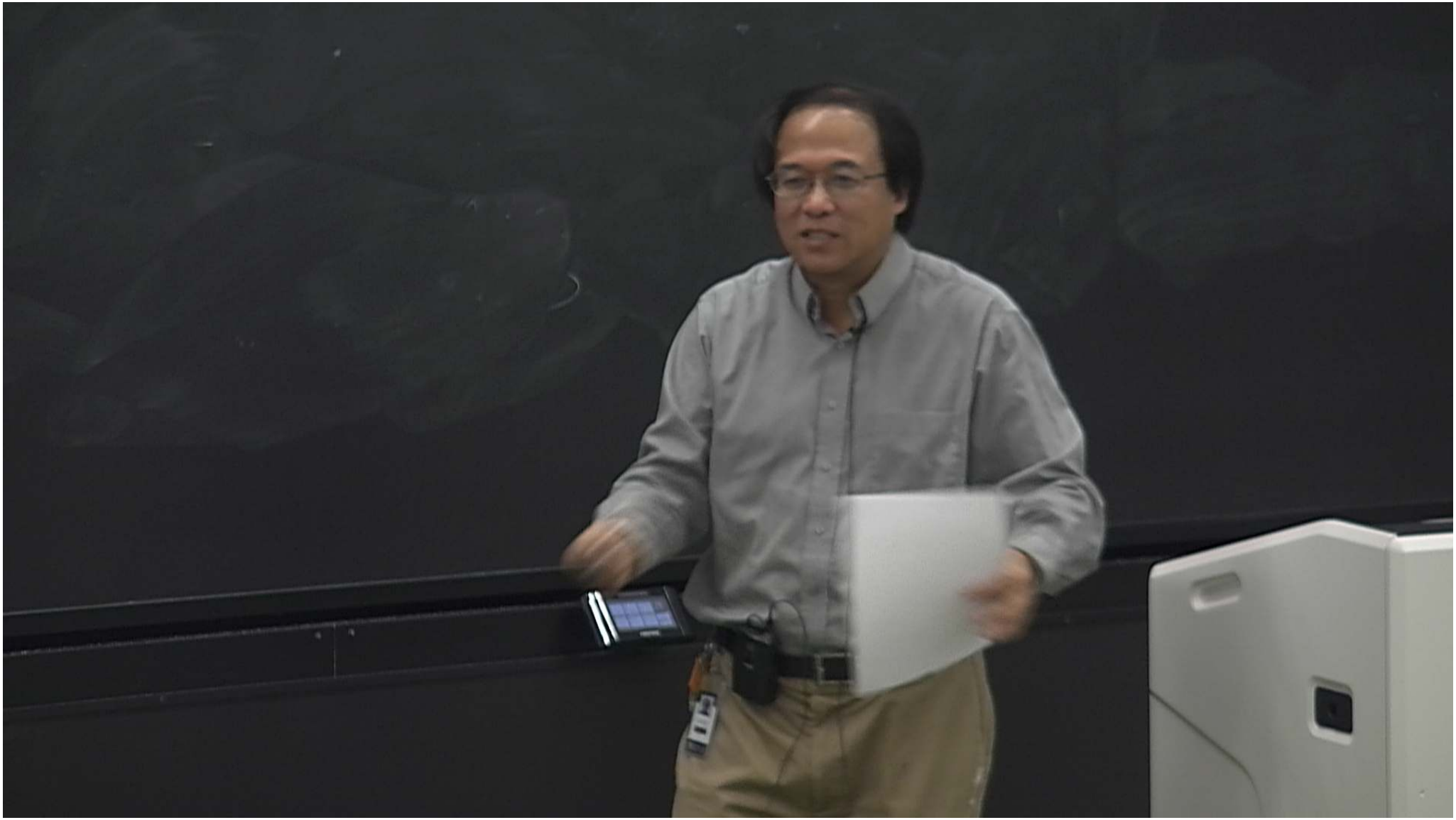

$\sigma^{xy} = \frac{e^2}{h} \frac{1}{2\pi} \int d^2k \; D^{xy}$
$2\pi \times \text{int}$
$D^{xy}\,\Delta k_x$
$D^{ij}(k) = \partial_i C_j - \partial_j C_i$
$C_i = i \psi^\dagger(k) \partial_i \psi(k)$
$\psi(k+\delta k) \rangle = e^{i\delta\phi}$
$\delta\phi = C_i$

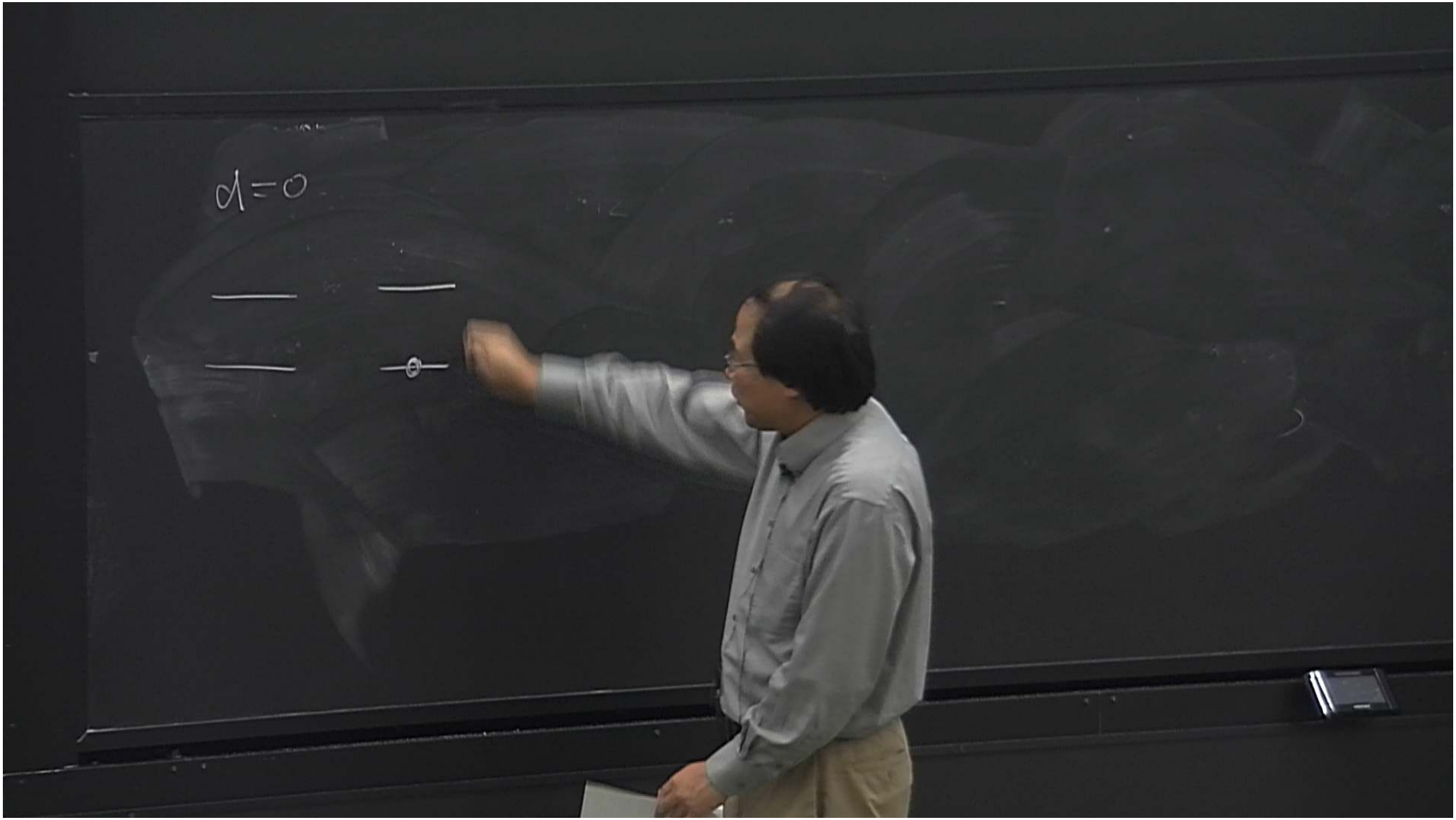


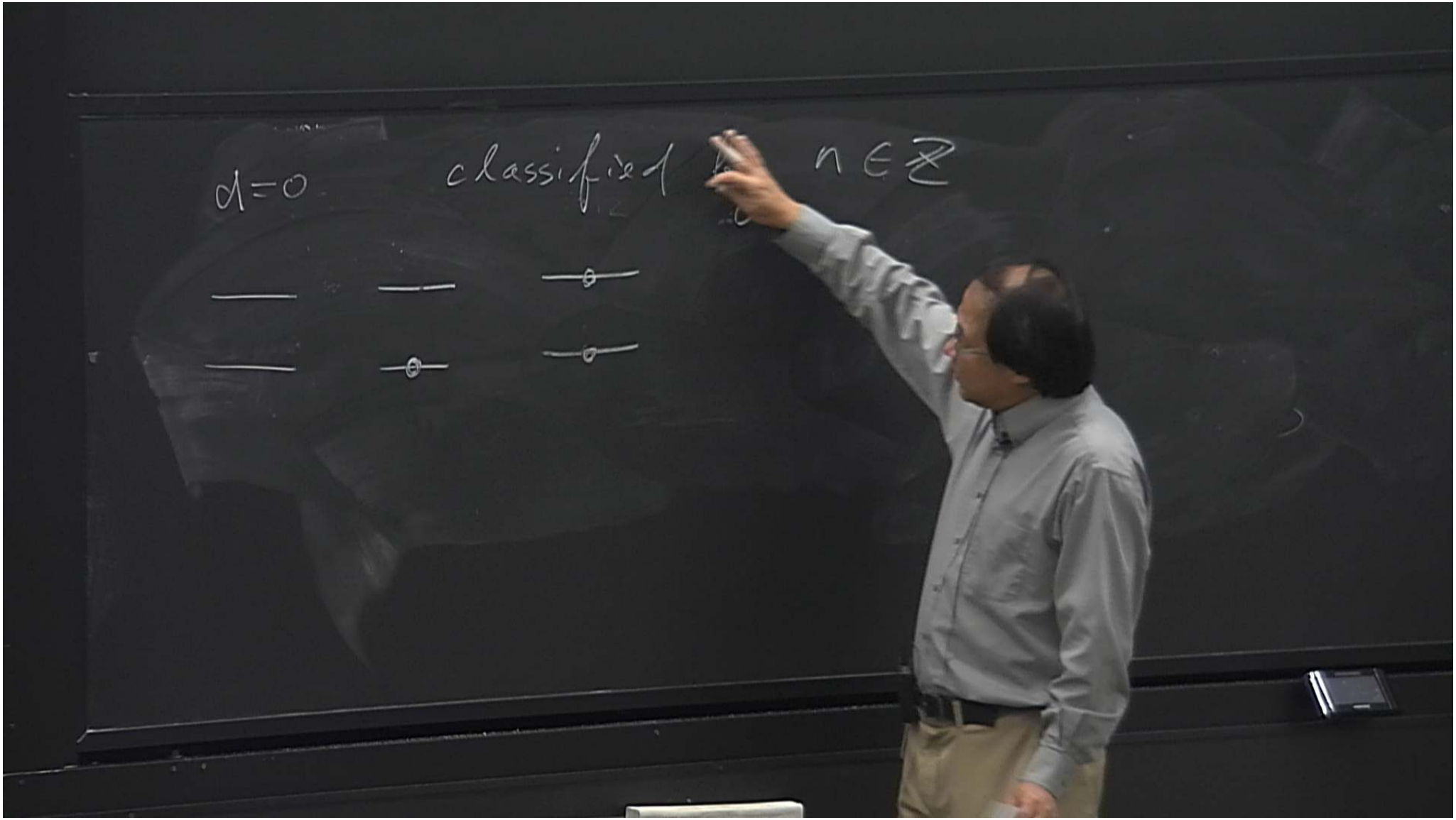
$\int d^2k \; D^{xy}$
$2\pi \times \text{int}$
$D^{xy} \Delta k_x \Delta k_y =$
$\delta\phi = c_i \cdot \delta k_i$
$\psi^\dagger(k) \partial_i \psi(k)$
$\psi(k+\delta k)\rangle = e^{i\delta\phi}$
$c = 1$
$c = -1$

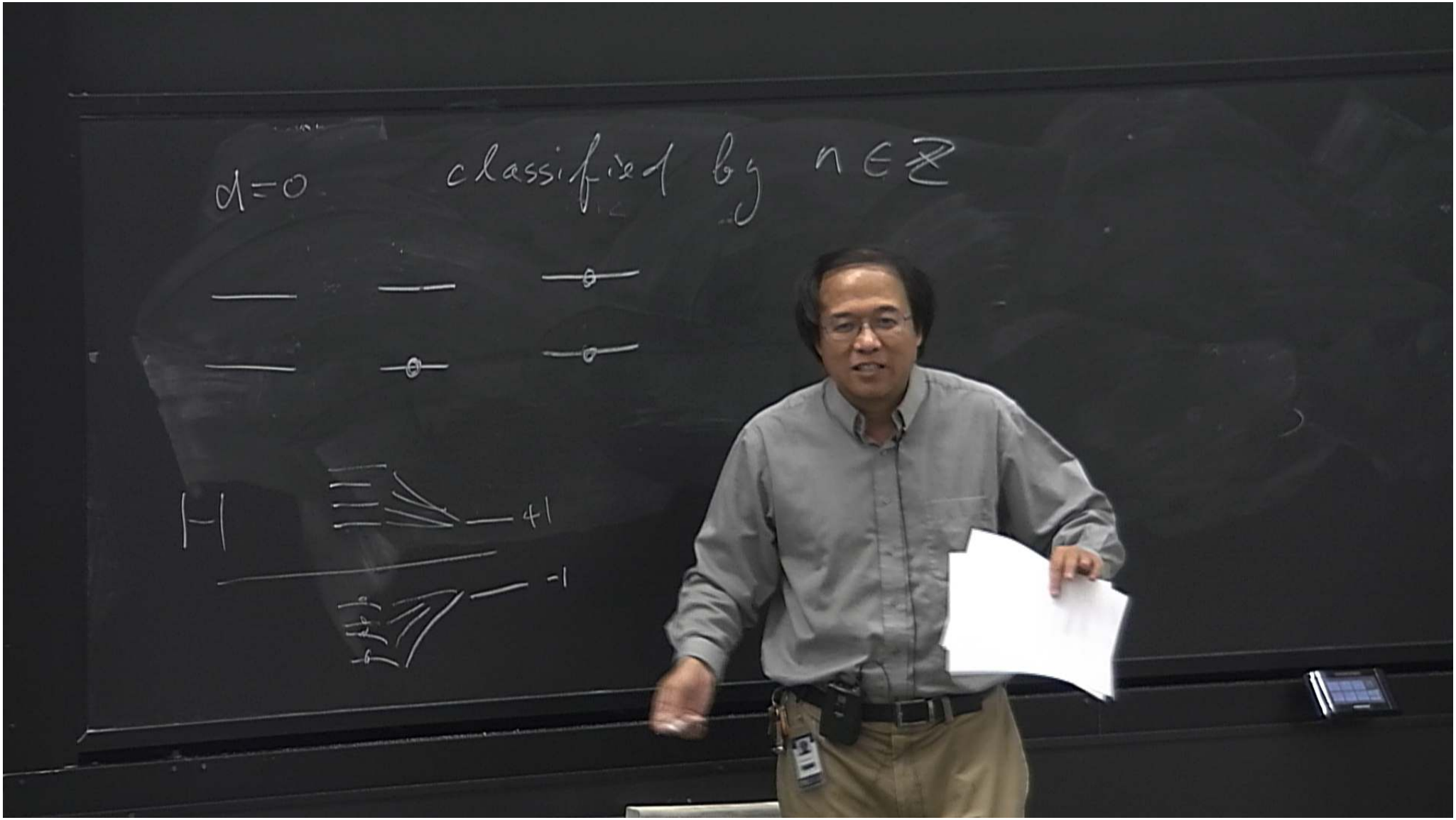

$M_{2\times 2}(\vec{k})$

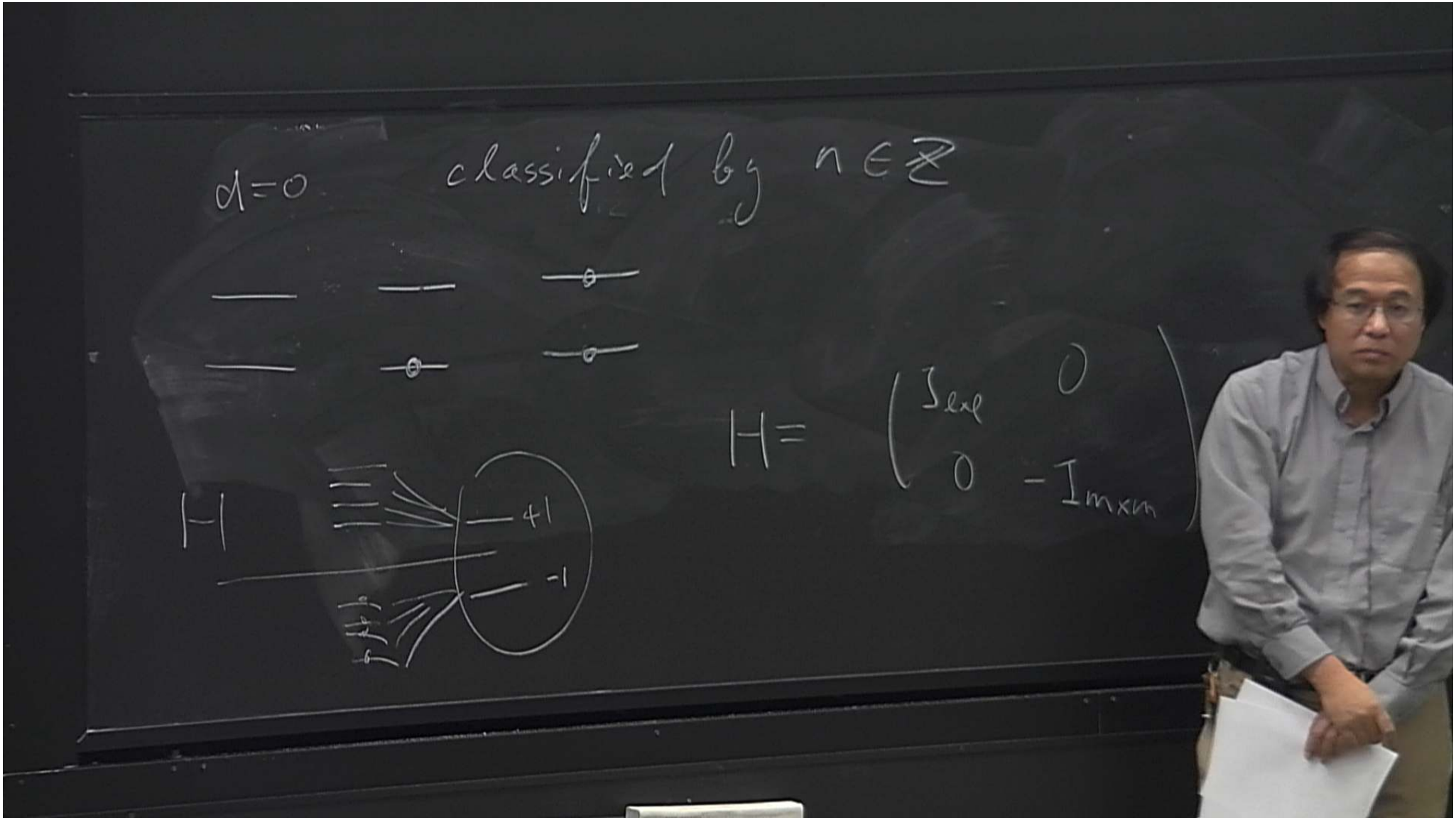

$M_{2\times 2}(\vec{k})$
$\in \mathbb{C}$?!
$= n_0 \mathbb{I} + n^i \sigma^i$
n_0 = const
$\pm |\vec{n}| \neq 0$
$\vec{n}(\vec{k})$:
$\vec{k}$

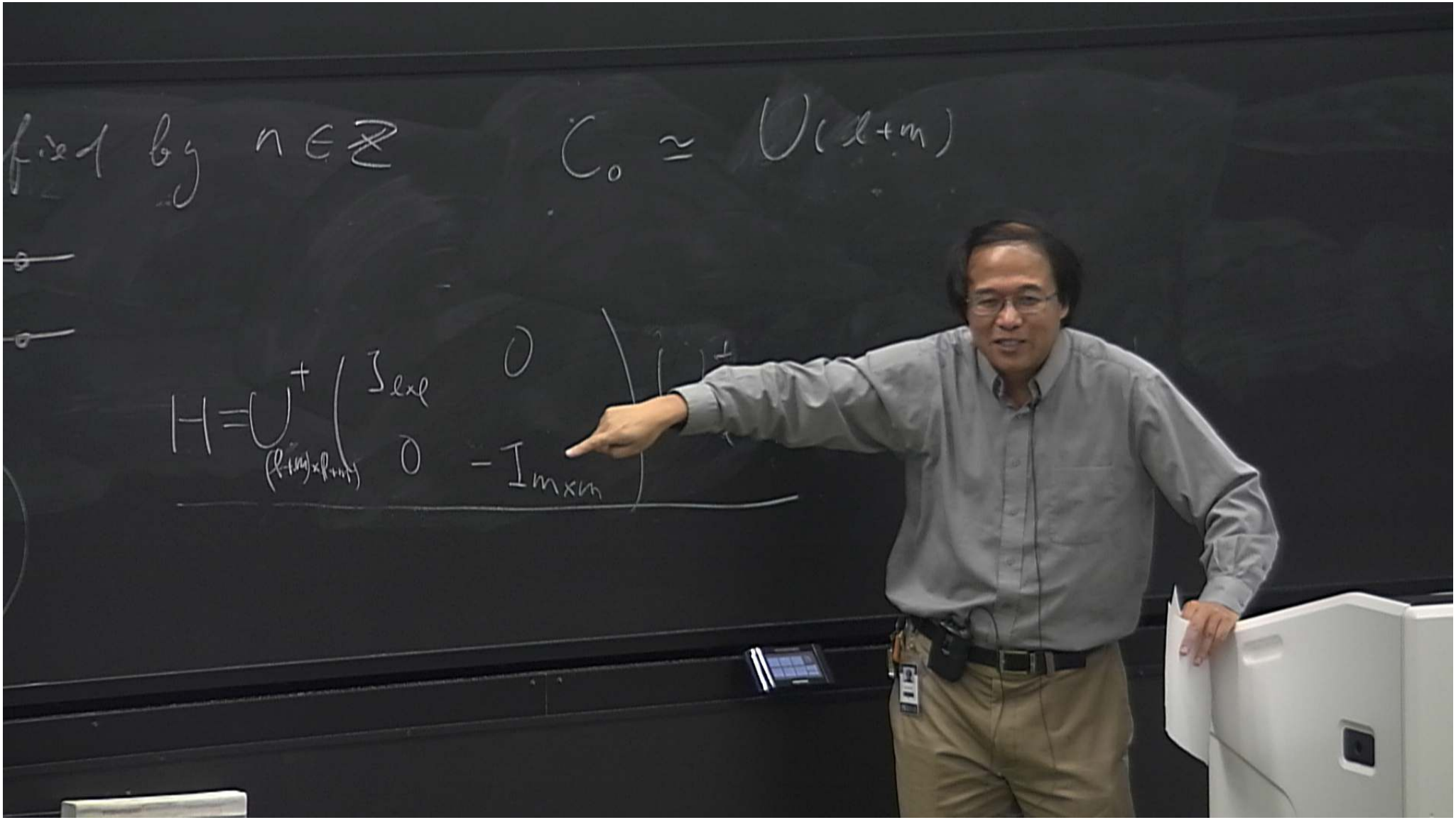


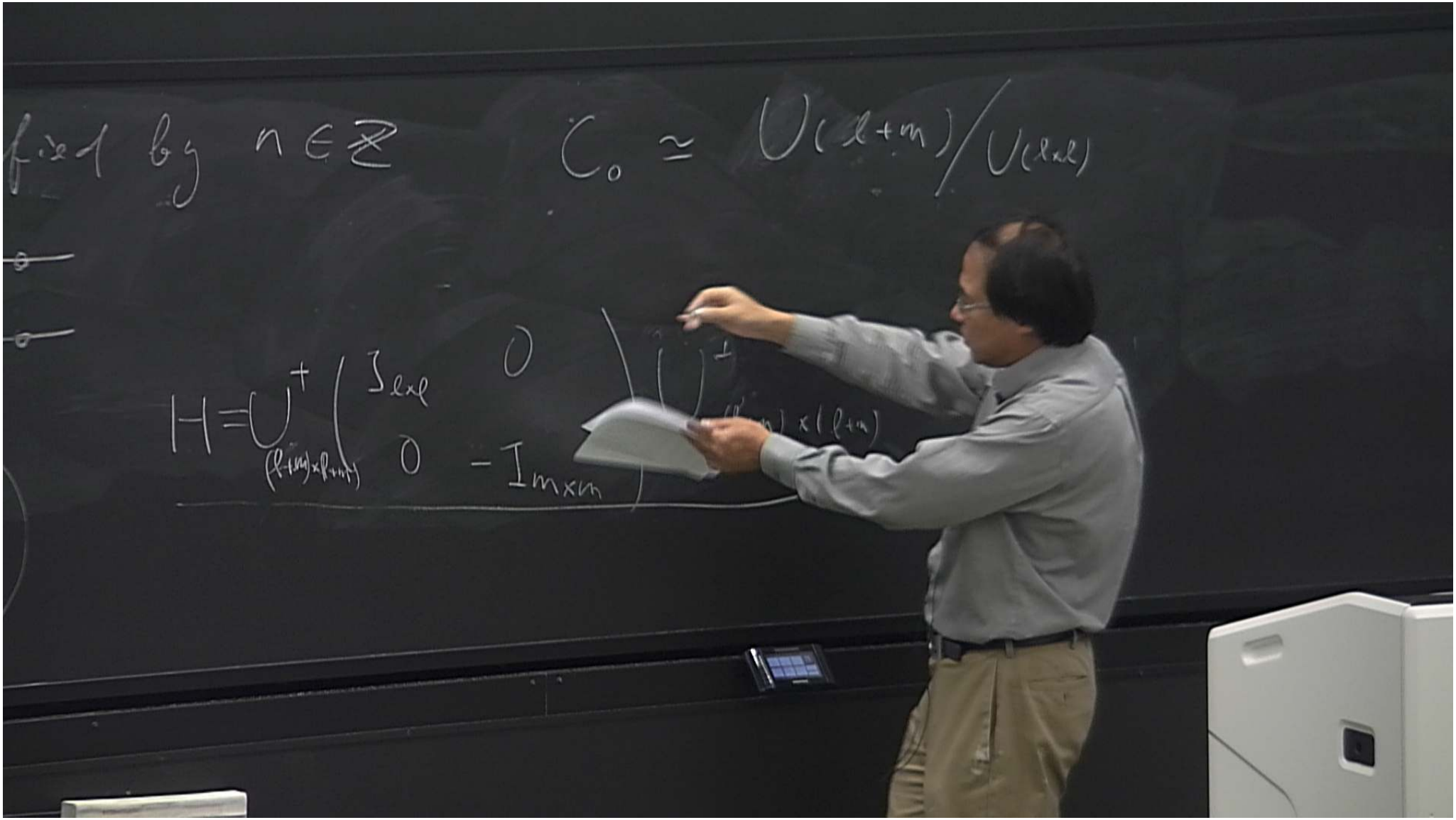

α=0

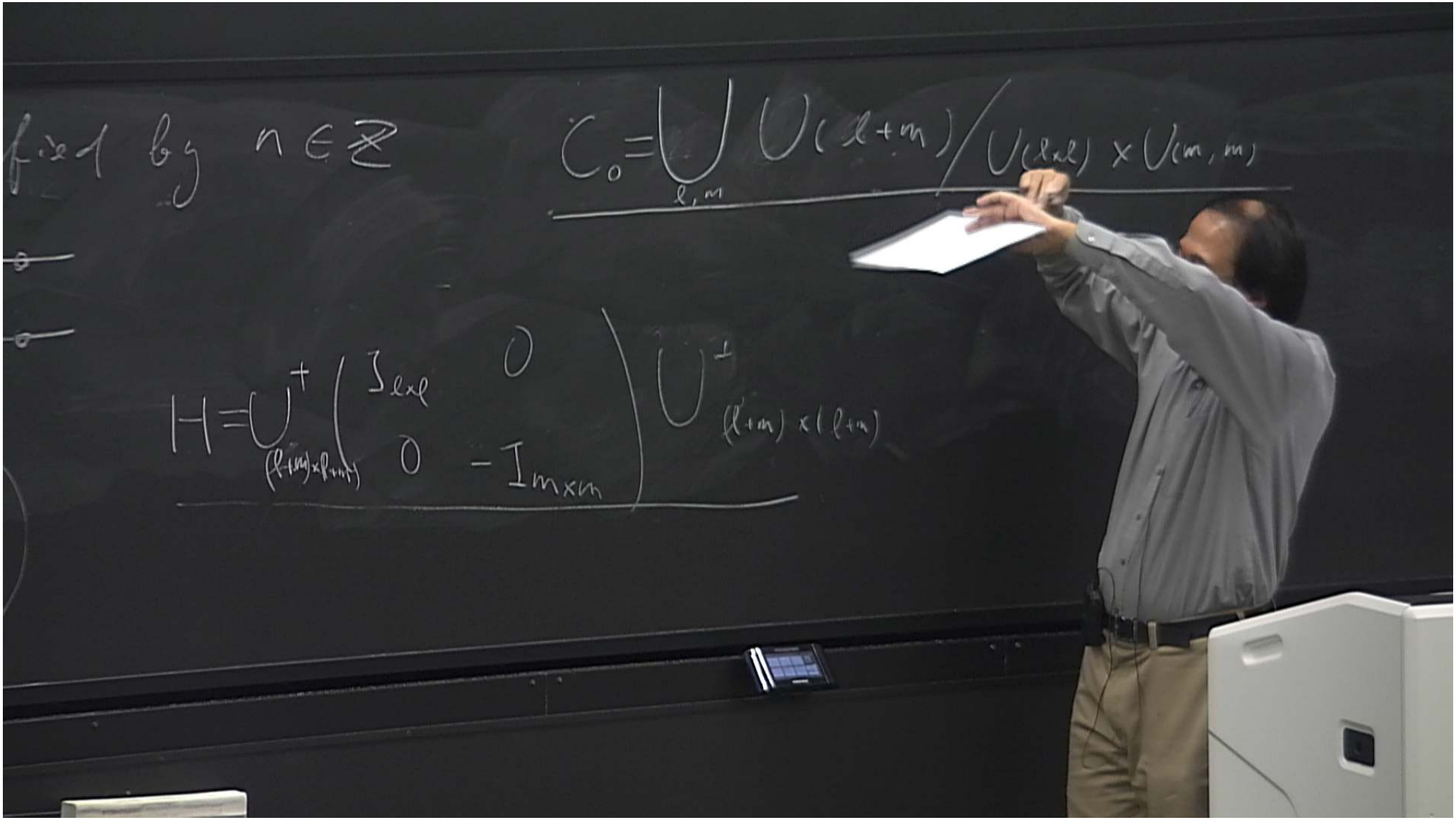

d=0
classified
n∈ℤ

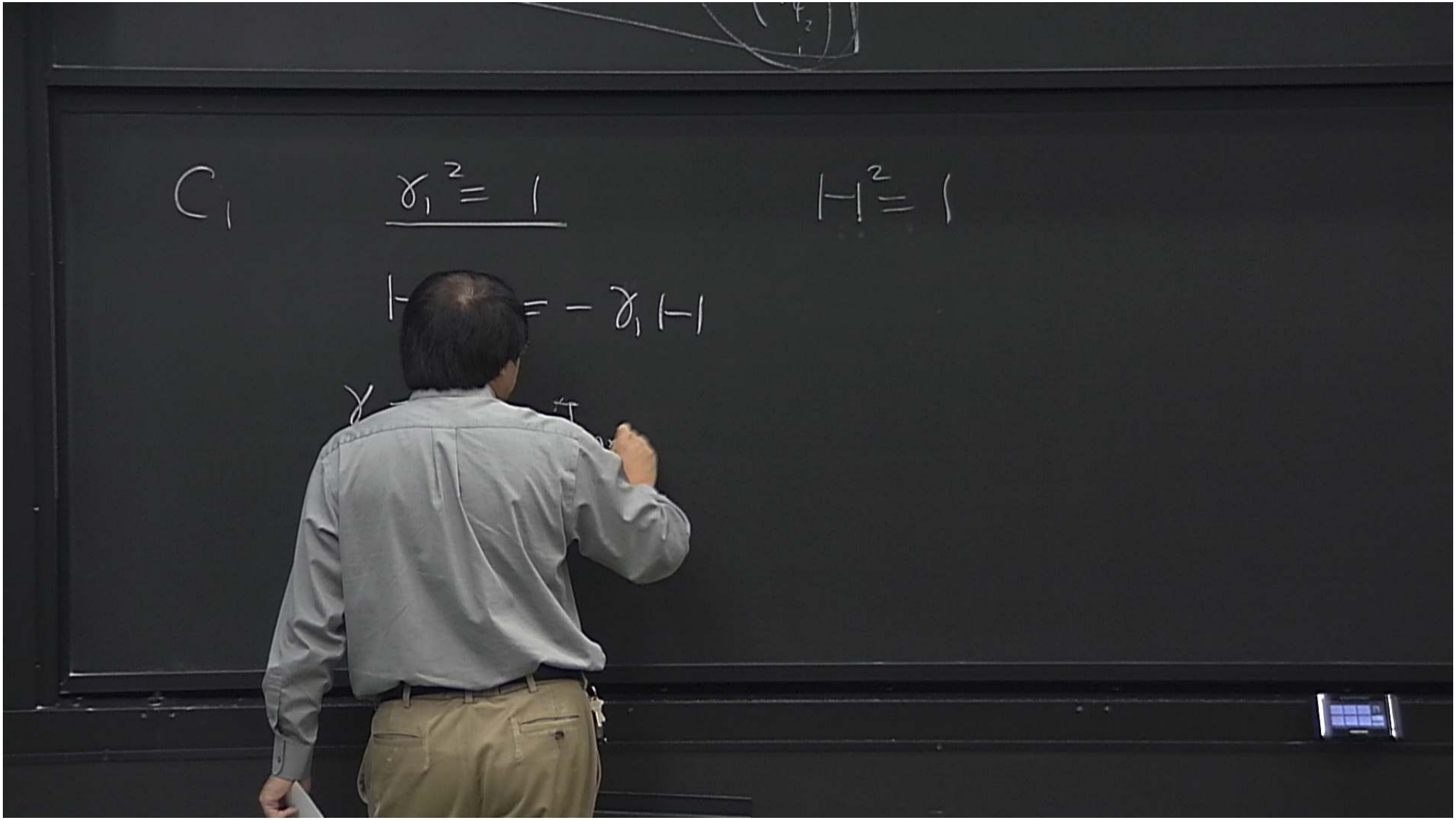

d=0
classified by n∈ℤ
H
+1
-1

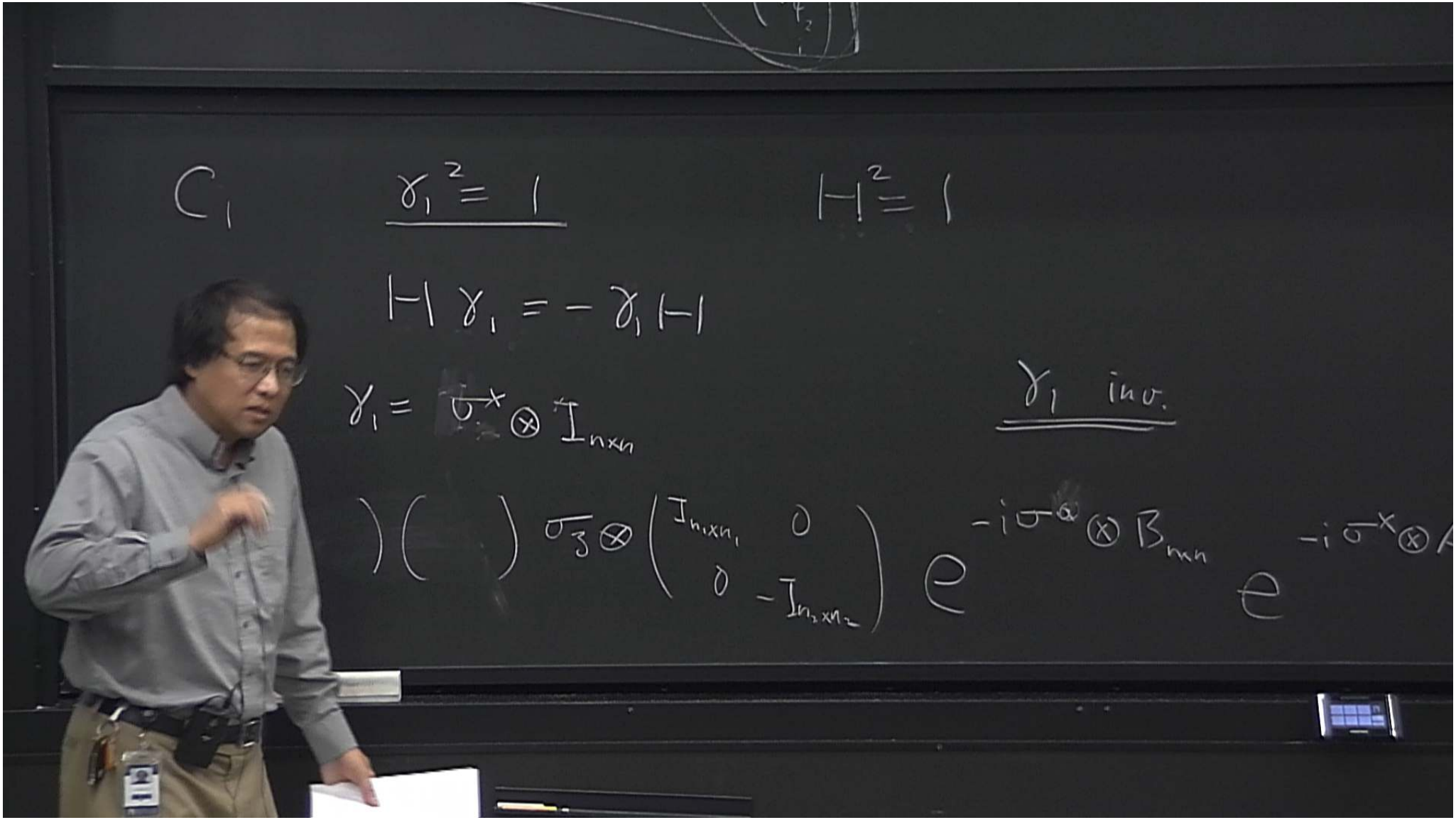

d=0
classified by n∈ℤ
H=
+1
-1

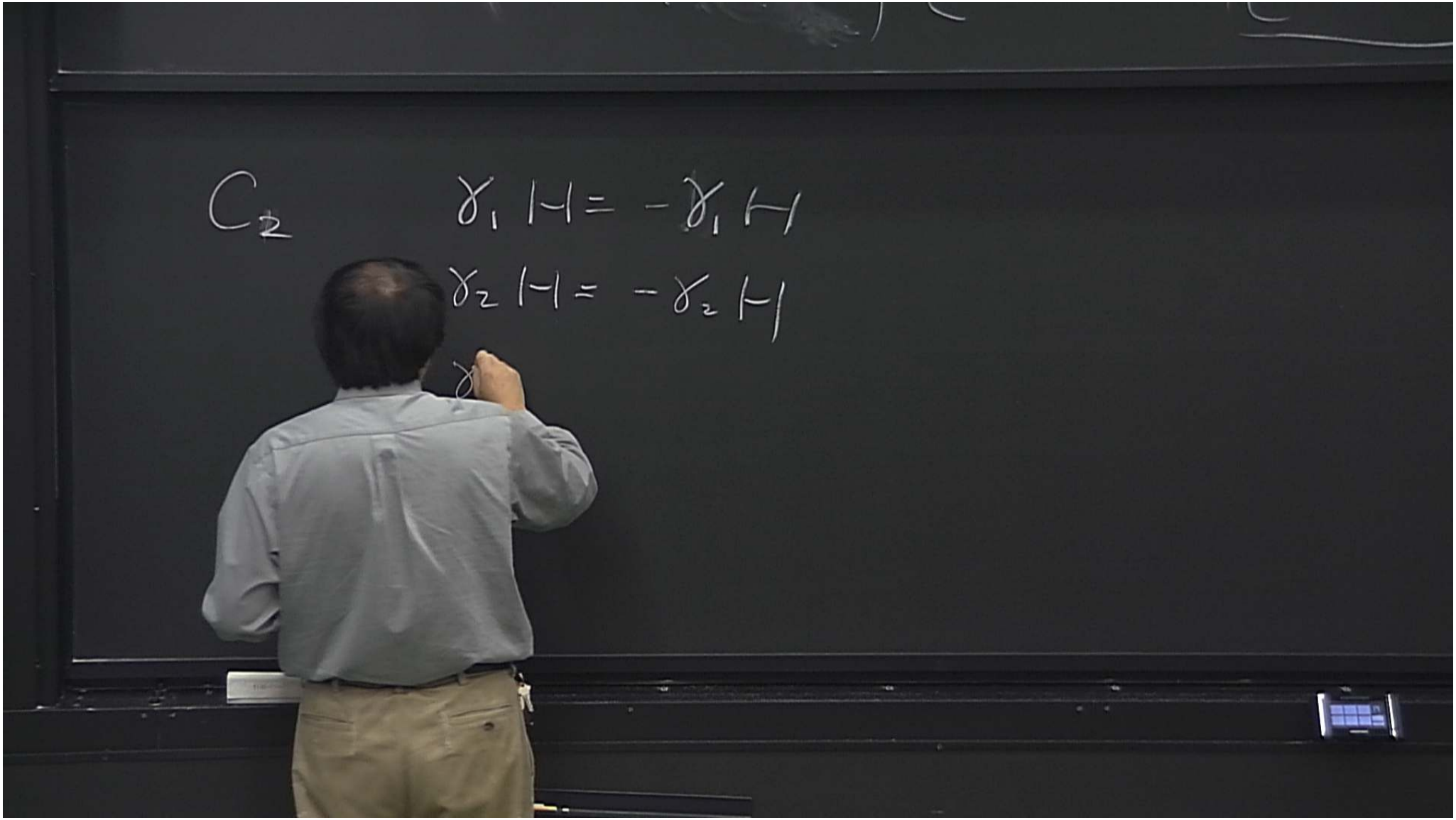

fixed by $n \in \mathbb{Z}$
$C_0 \simeq U(\ell+m)$
$H = U^{\dagger}$
$I_{\ell \times \ell}$
0
0
$-I_{m \times m}$

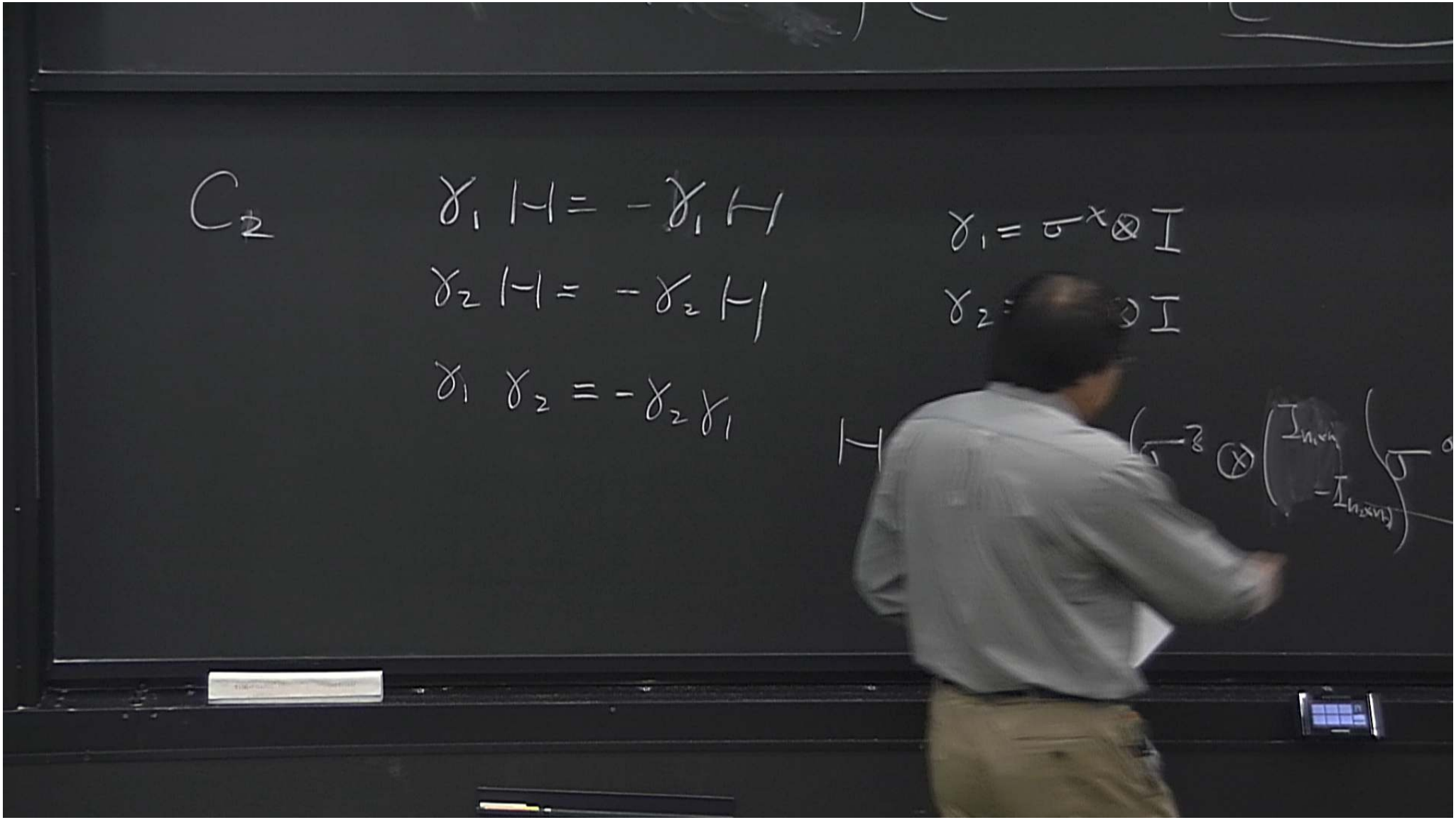

fixed by $n \in \mathbb{Z}$
$C_0 \simeq U(\ell+m)/U(\ell)\times U(m)$
$H = U^{\dagger}$
$I_{\ell\times\ell}$
0
0
$-I_{m\times m}$

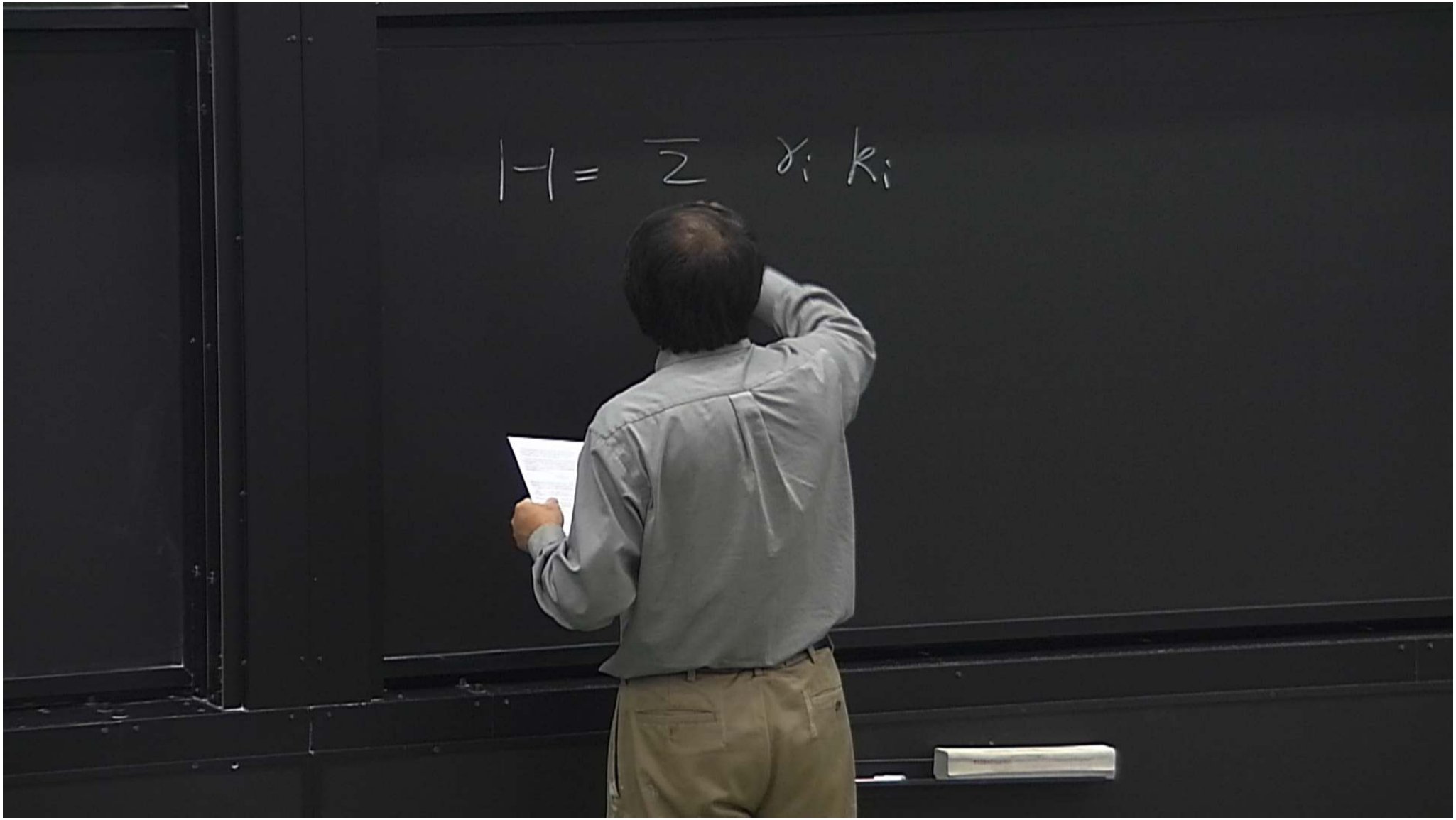

fixed by $n \in \mathbb{Z}$
$C_0 = \bigcup_{\ell,m} U(\ell+m) / U(\ell) \times U(m,m)$
$H = U^{\dagger}_{(\ell+m)\times(\ell+m)} \begin{pmatrix} I_{\ell\times\ell} & 0 \\ 0 & -I_{m\times m} \end{pmatrix} U_{(\ell+m)\times(\ell+m)}$

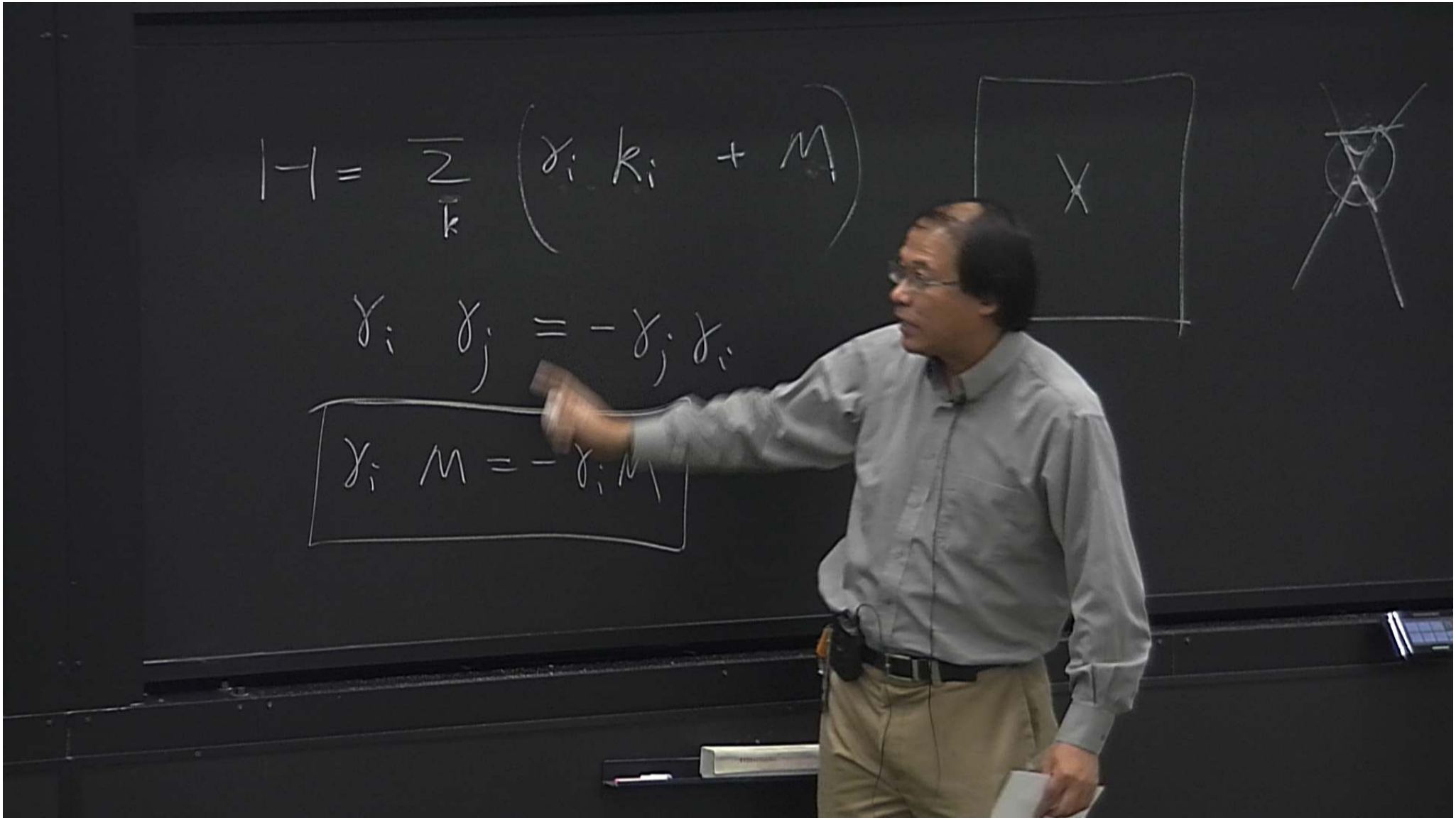

C_1
$\gamma_1^2 = 1$
$H_1^2 = 1$
$= -\gamma_1 H_1$

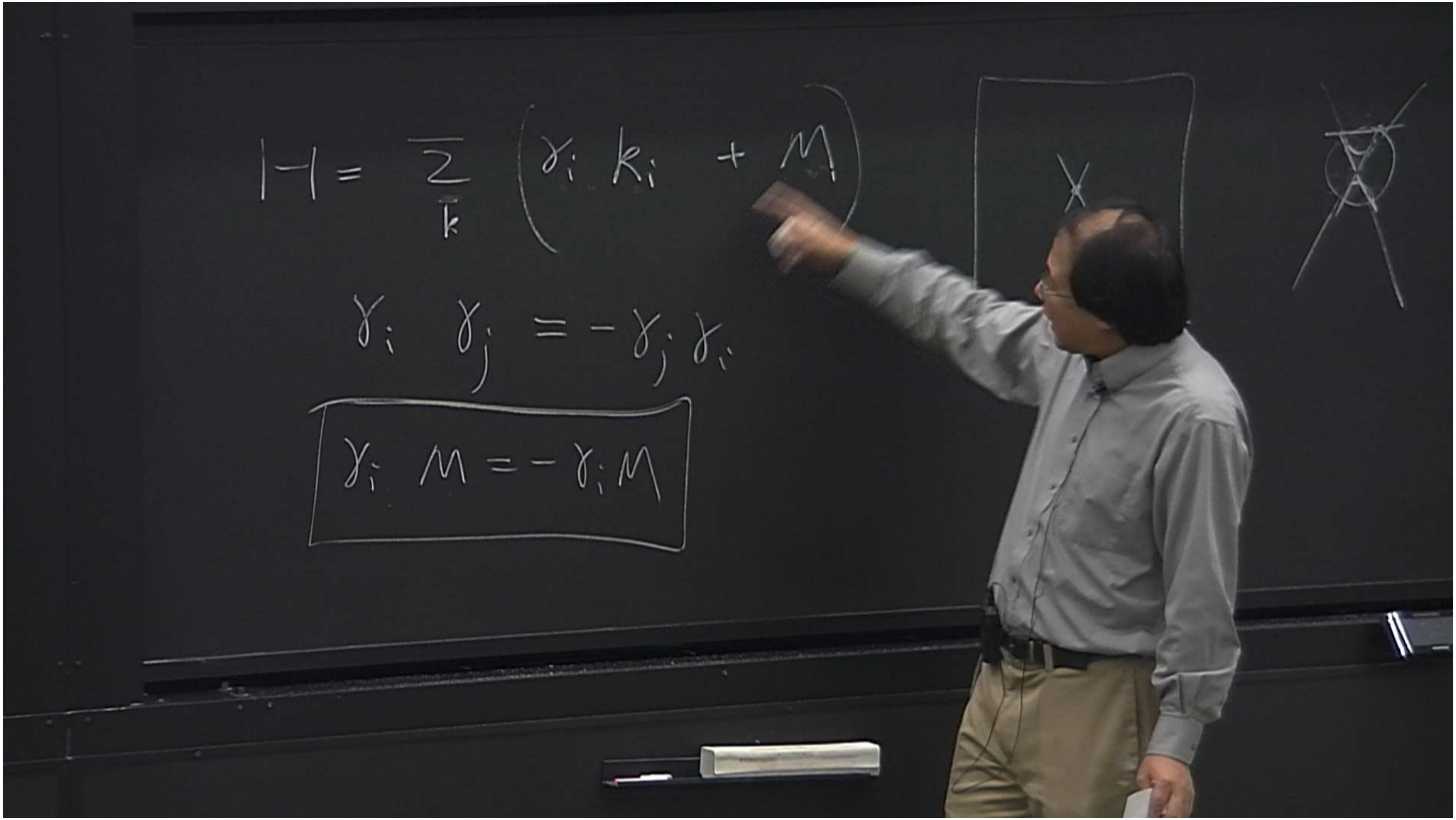

C_1
$\gamma_1^2 = 1$
$H^2 = 1$
$H\gamma_1 = -\gamma_1 H$
$\gamma_1 = \sigma^x \otimes I_{n\times n}$
γ_1 inv.
$\sigma_3 \otimes \begin{pmatrix} I_{n_1\times n_1} & 0 \\ 0 & -I_{n_2\times n_2} \end{pmatrix}$
$e^{-i\sigma^\alpha \otimes B_{n\times n}}$
$e^{-i\sigma^x \otimes$

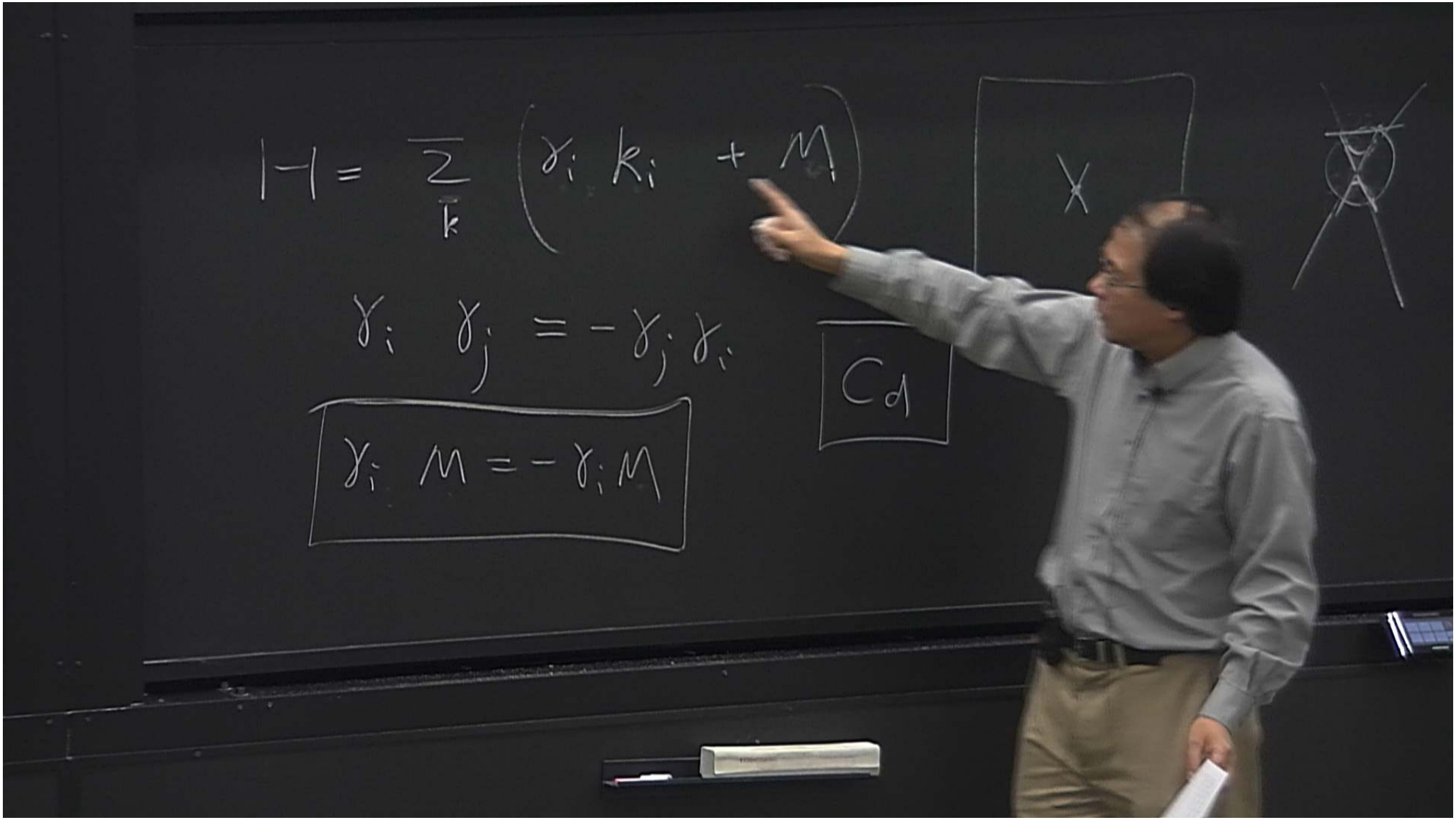

C_2
$\gamma_1 |H\rangle = -\gamma_1 |H\rangle$
$\gamma_2 |H\rangle = -\gamma_2 |H\rangle$
γ

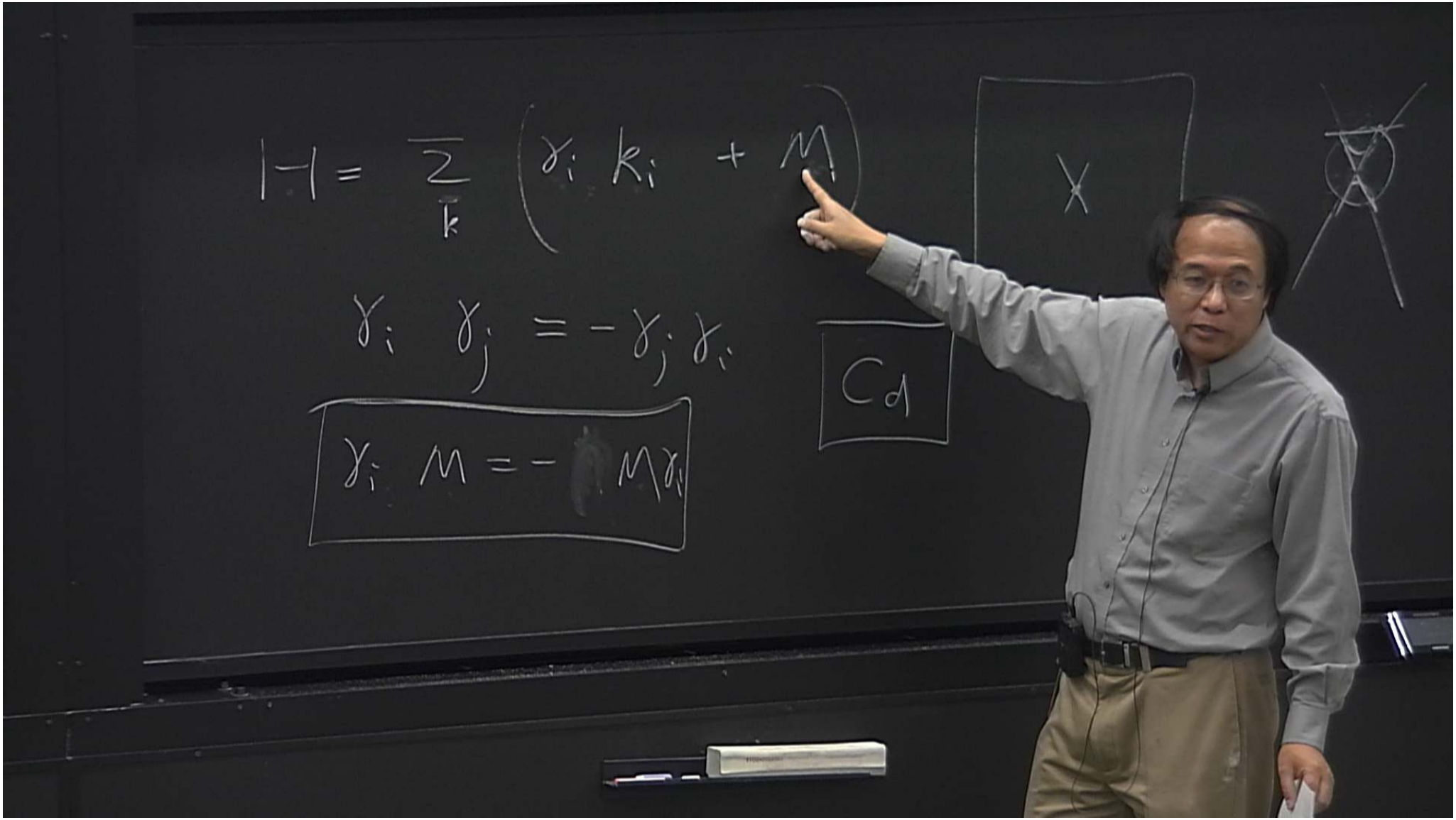

C_2
$\gamma_1 H = -\gamma_1 H$
$\gamma_2 H = -\gamma_2 H$
$\gamma_1 \gamma_2 = -\gamma_2 \gamma_1$
$\gamma_1 = \sigma^x \otimes I$


H = Σ γ_i k_i


$H = \sum_k (\gamma_i k_i + M)$
$\gamma_i \gamma_j = -\gamma_j \gamma_i$
$\gamma_i M = -\gamma_i M$
X


$H = \sum_k (\gamma_i k_i + M)$
$\gamma_i \gamma_j = -\gamma_j \gamma_i$
$\gamma_i M = -\gamma_i M$


$H = \sum_k (\gamma_i k_i + M)$
$\gamma_i \gamma_j = -\gamma_j \gamma_i$
$\gamma_i M = -\gamma_i M$
Cd


$H = \sum_k (\gamma_i k_i + M)$
$\gamma_i \gamma_j = -\gamma_j \gamma_i$
$\gamma_i M = - M \gamma_i$
Cd
X