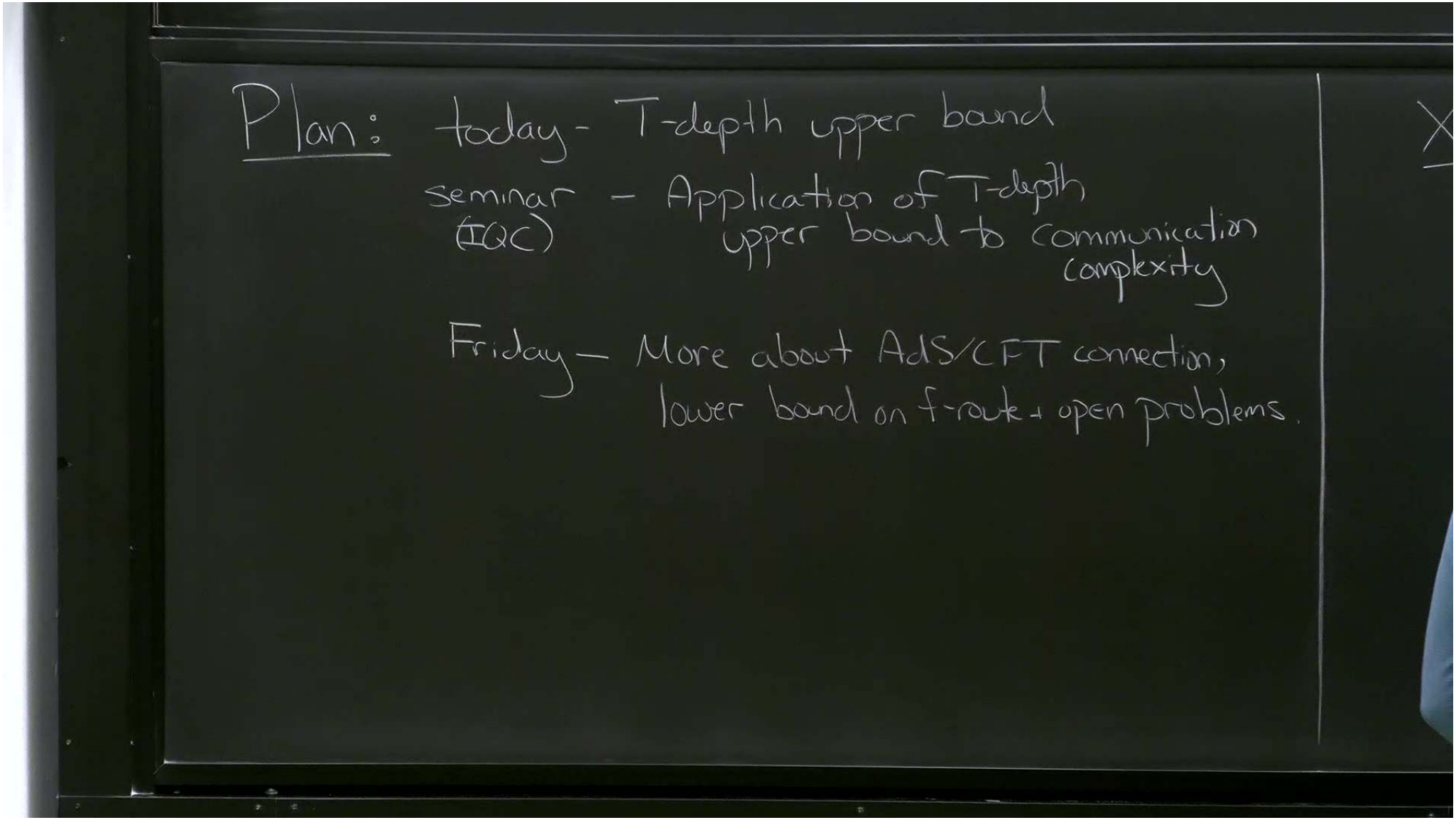
Title: Lecture - Non-local quantum computation mini course

Speakers: Alex May

Collection/Series: Non-local quantum computation mini-course, May 4-15, 2026

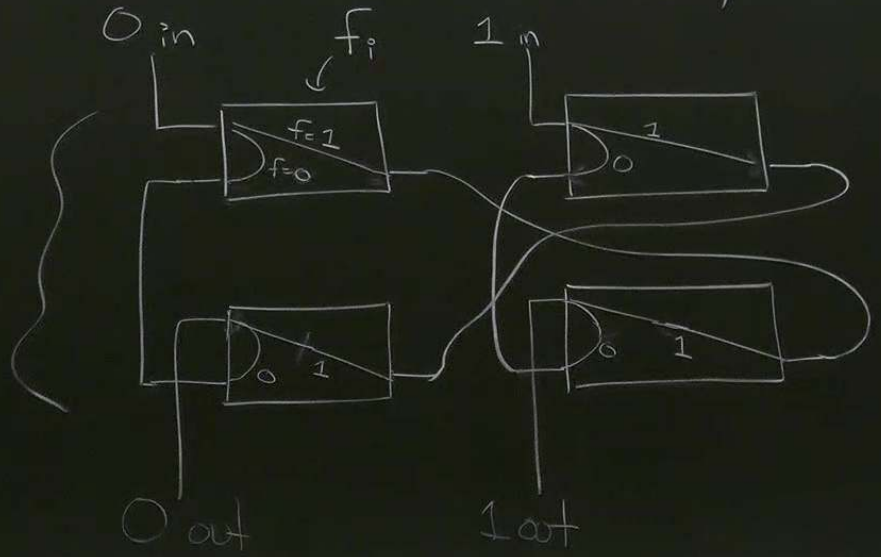
Date: May 13, 2026 - 2:00 PM

URL: https://pirsa.org/26050007


Plan: today - T-depth upper bound
seminar (IQC) - Application of T-depth upper bound to communication complexity
Friday - More about AdS/CFT connection, lower bound on f-rank + open problems.

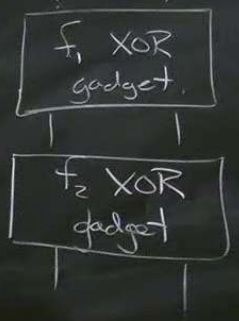
XOR Lemma

$$GH\left(\bigoplus_{i=1}^{k} f_i\right) \leq 4 \sum_{i=1}^{k} GH(f_i)$$



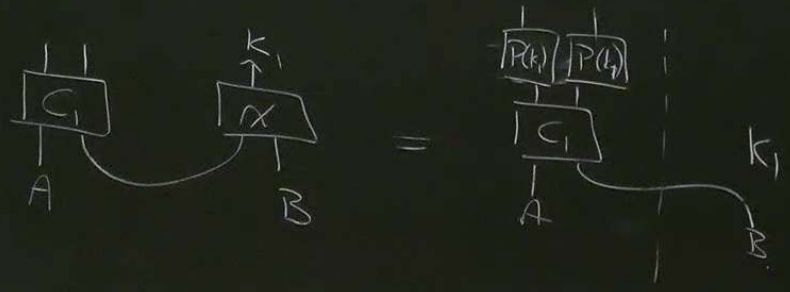
14)

$f_1 \oplus f_2$

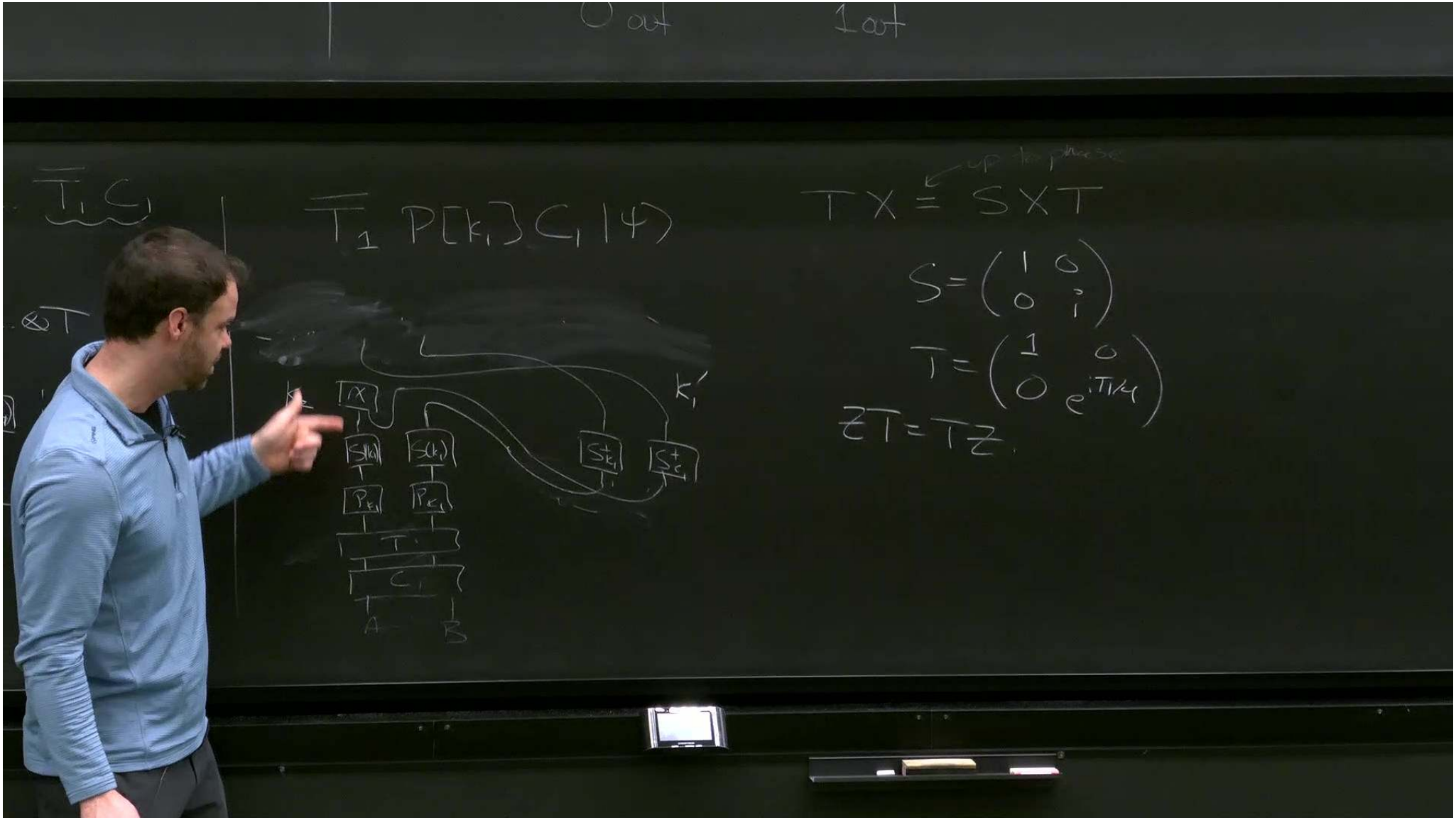


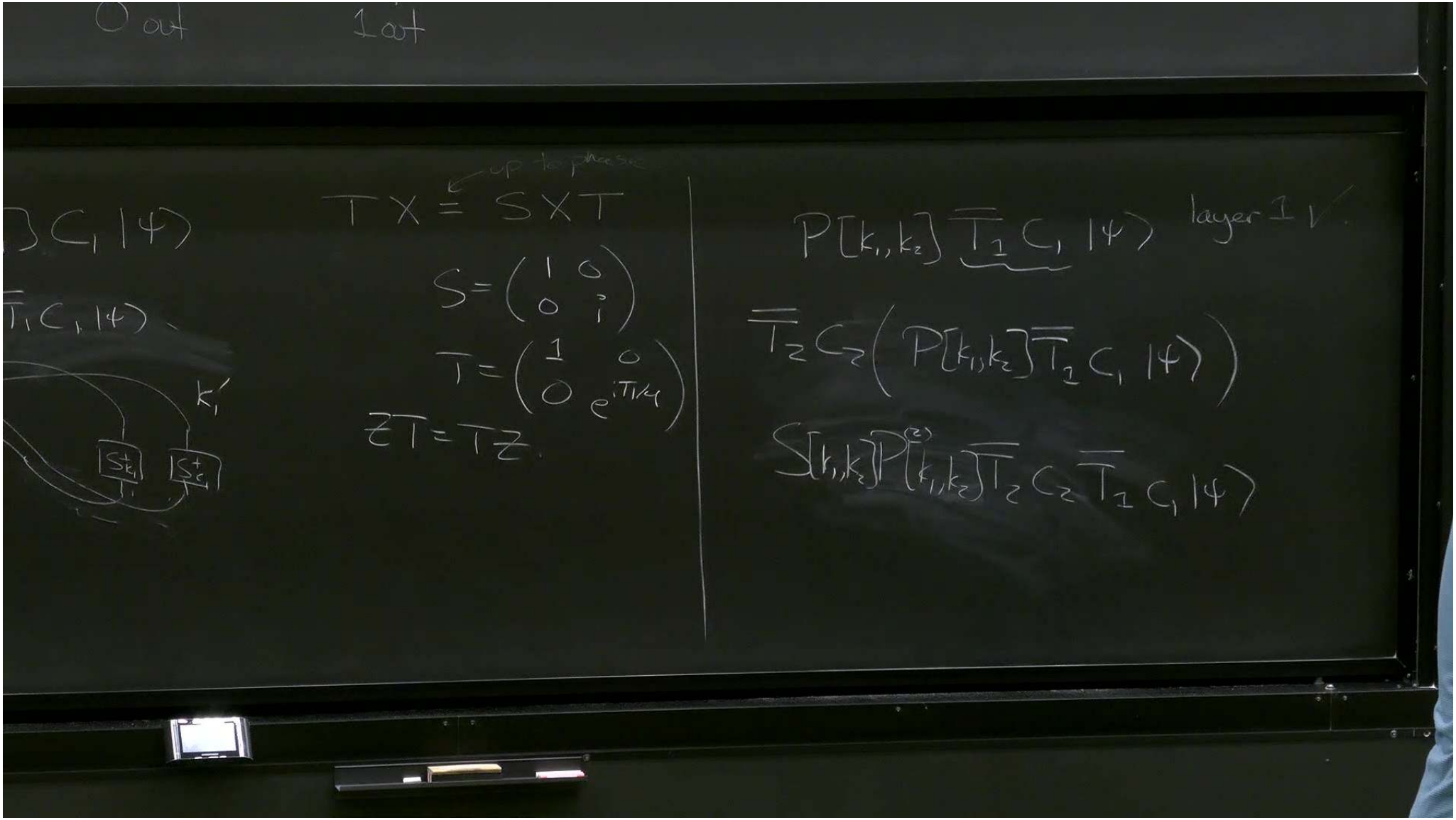
$$U = C_{d+1}\,\overline{T}_d\,C_d \cdots \overline{T}_1 C_1$$

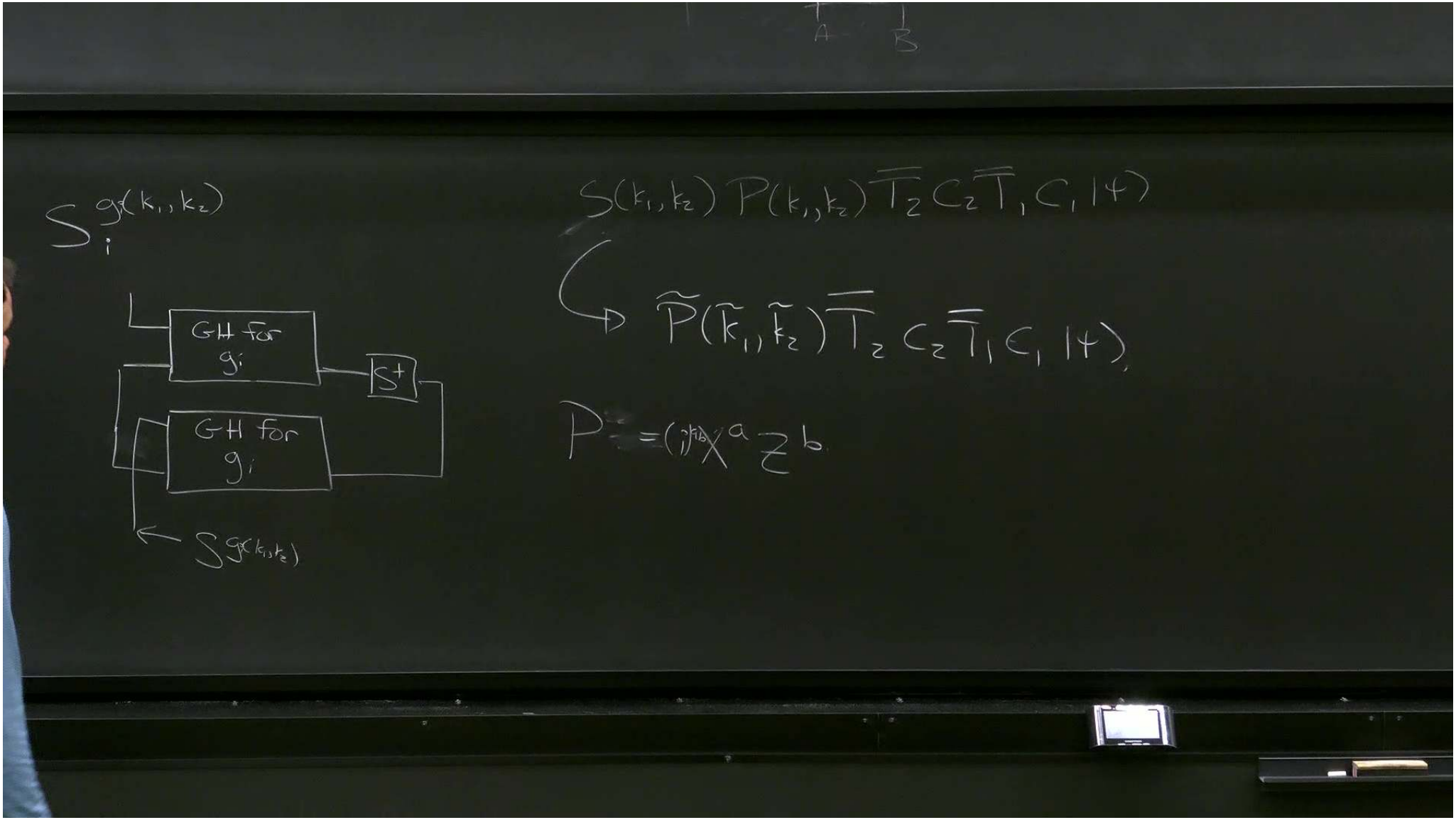
$$\overline{T}_i = T \otimes \mathbb{I} \otimes \cdots \otimes T$$

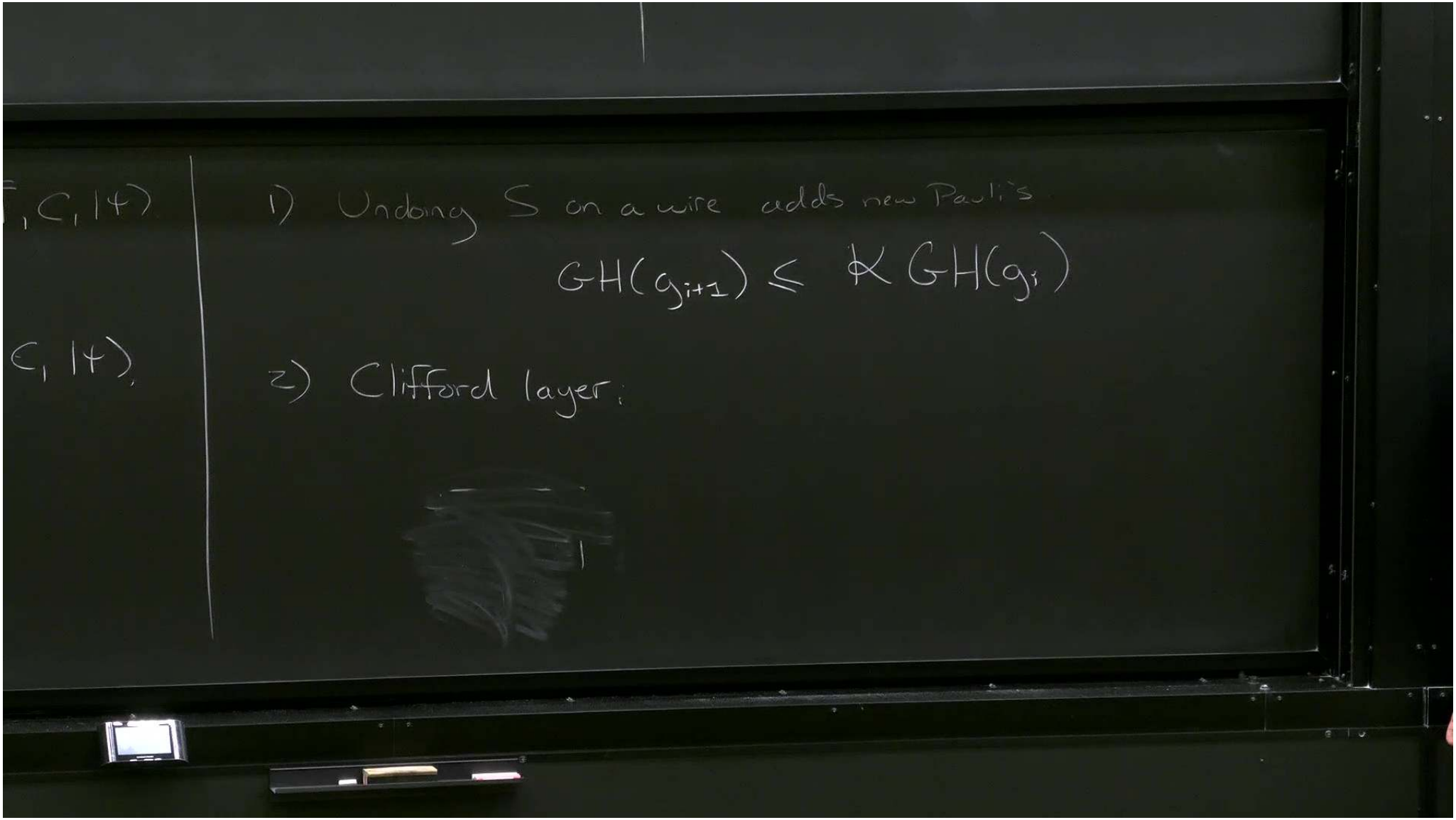


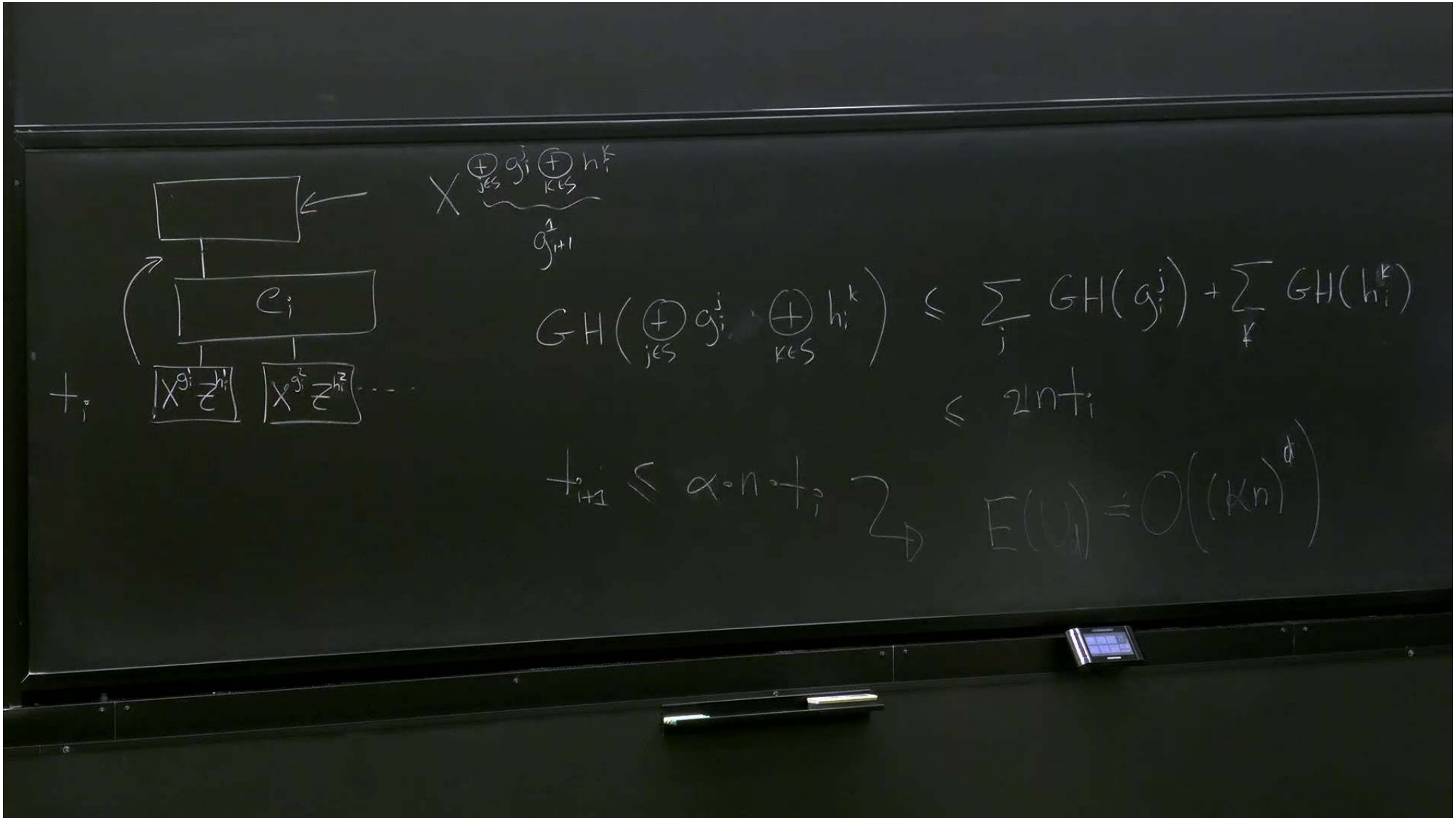
$$\overline{T}_1\,P[k_1]\,C_1\,|\psi\rangle$$

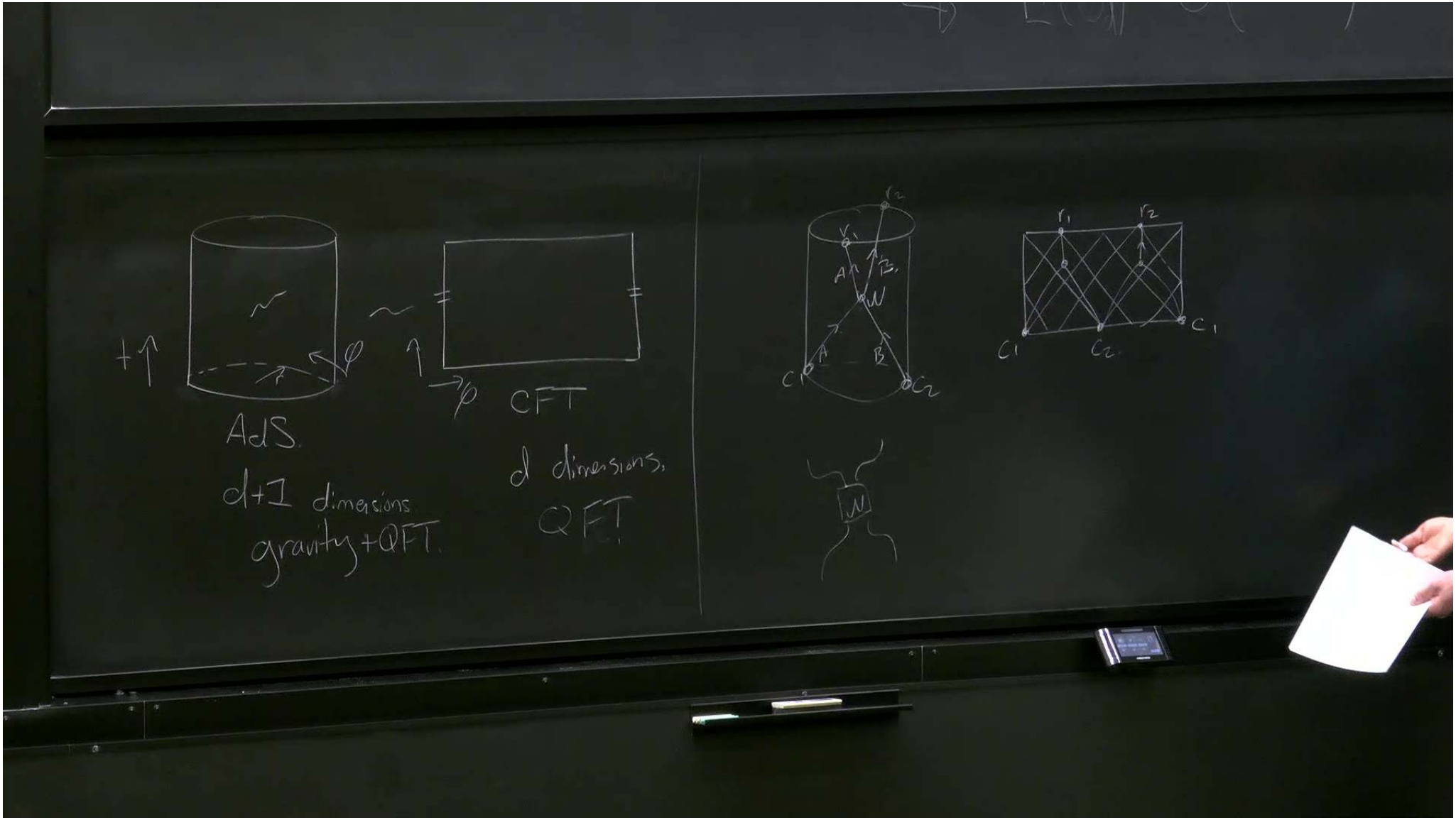

0 out
1 out
$\overline{T}_1 P[k_1] C_1 |\psi\rangle$
$TX = SXT$
$S = \begin{pmatrix} 1 & 0 \\ 0 & i \end{pmatrix}$
$T = \begin{pmatrix} 1 & 0 \\ 0 & e^{i\pi/4} \end{pmatrix}$
$ZT = TZ$
A
B

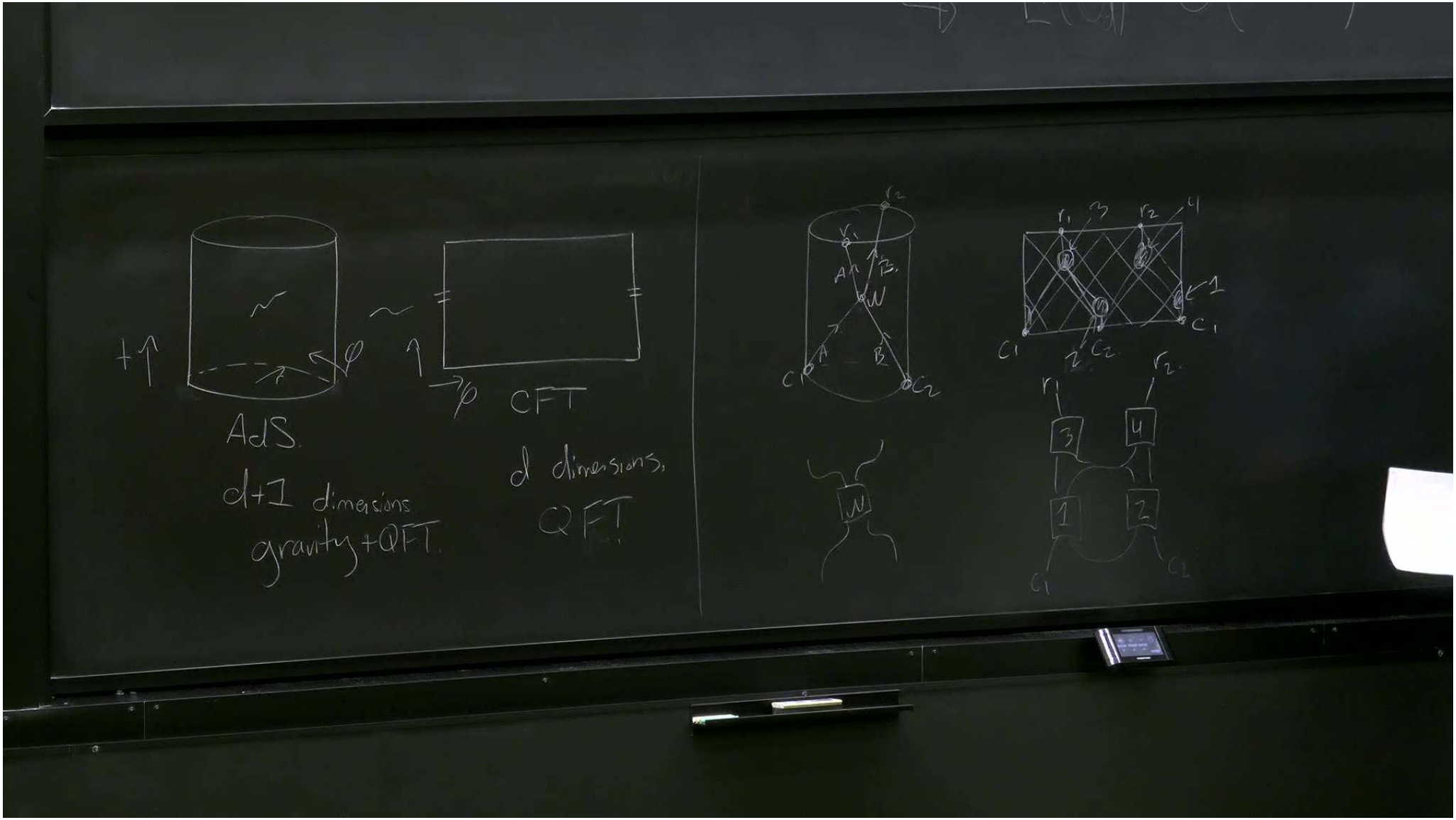

0 out
1 out
up to phase
$TX = SXT$
$S = \begin{pmatrix} 1 & 0 \\ 0 & i \end{pmatrix}$
$T = \begin{pmatrix} 1 & 0 \\ 0 & e^{i\pi/4} \end{pmatrix}$
$ZT = TZ$
$P[k_1,k_2]\,\overline{T}_1 C_1 |\psi\rangle$ layer 1
$\overline{T}_2 C_2 \left(P[k_1,k_2]\,\overline{T}_1 C_1 |\psi\rangle \right)$
$S[k_1,k_2] P^{(2)}[k_1,k_2]\,\overline{T}_2 C_2 \overline{T}_1 C_1 |\psi\rangle$
k_1'


A
B
$S_i^{g_i(k_1,k_2)}$
GH for g_i
$S^\dagger$
GH for g_i
$S^{g_i(k_1,k_2)}$
$S(k_1,k_2)\,P(k_1,k_2)\,\bar{T}_2 C_2 \bar{T}_1 C_1 |\psi\rangle$
$\tilde{P}(\tilde{k}_1,\tilde{k}_2)\,\bar{T}_2 C_2 \bar{T}_1 C_1 |\psi\rangle$
$P = (\quad)^{k_1 k_2} X^a Z^b$


, C, 1+)
C, 1+),
1) Undoing S on a wire adds new Pauli's
GH(g_{i+1}) ≤ 4 GH(g_i)
2) Clifford layer:

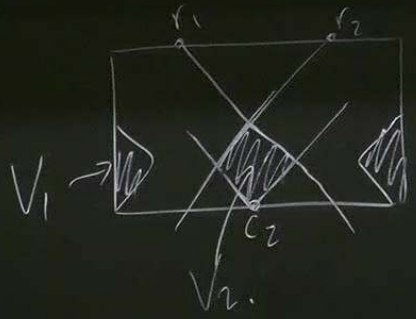

C_i
$X^{g_i^1} Z^{h_i^1}$
$X^{g_i^2} Z^{h_i^2}$
t_i
$X \underbrace{\bigoplus_{j\in S} g_i^j \bigoplus_{k\in S} h_i^k}_{g_{i+1}^1}$
$GH\left(\bigoplus_{j\in S} g_i^j \bigoplus_{k\in S} h_i^k\right) \le \sum_j GH(g_i^j) + \sum_k GH(h_i^k)$
$\le 2nt_i$
$t_{i+1} \le a \cdot n \cdot t_i$ 2-design $E(U_t) = O((kn)^d)$

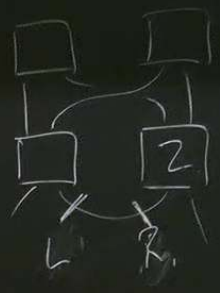

AdS
d+1 dimensions
gravity + QFT
CFT
d dimensions
QFT
W

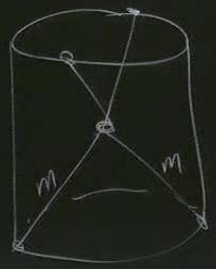

AdS
d+1 dimensions
gravity + QFT
CFT
d dimensions,
QFT

gravity + QFT.

QFT



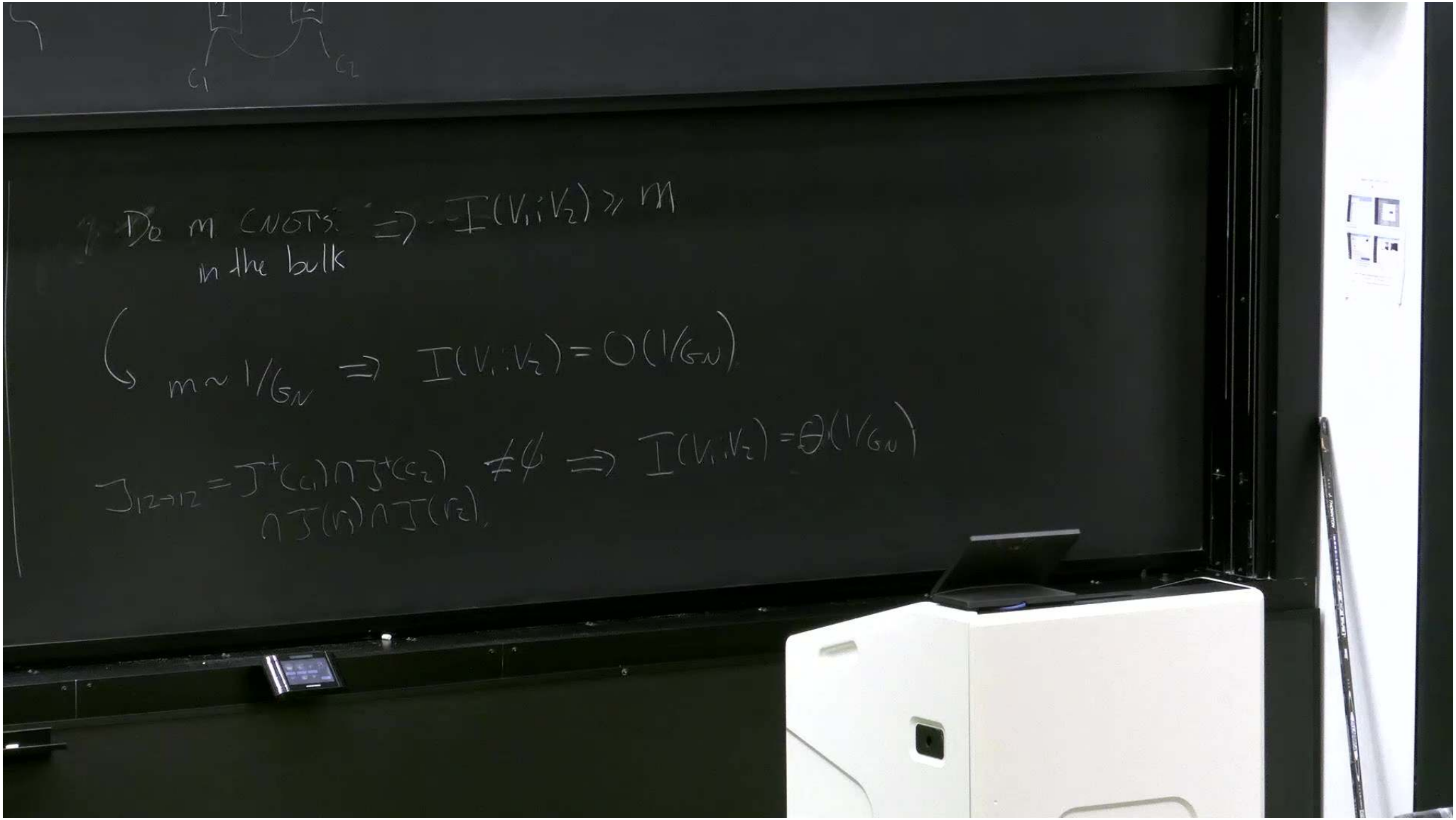




$\otimes m$.

$I(L:R) \geq m$

Do m CNOTs in the bulk $\Rightarrow$ $I(V_1 : V_2) \geq m$


Do m CNOTs: ⇒ I(V1:V2) ≥ m
in the bulk
m ~ 1/GN ⇒ I(V1:V2) = O(1/GN)
J12→12 = J+(C1) ∩ J+(C2) ∩ J(r1) ∩ J(r2) ≠ ∅ ⇒ I(V1:V2) = Θ(1/GN)