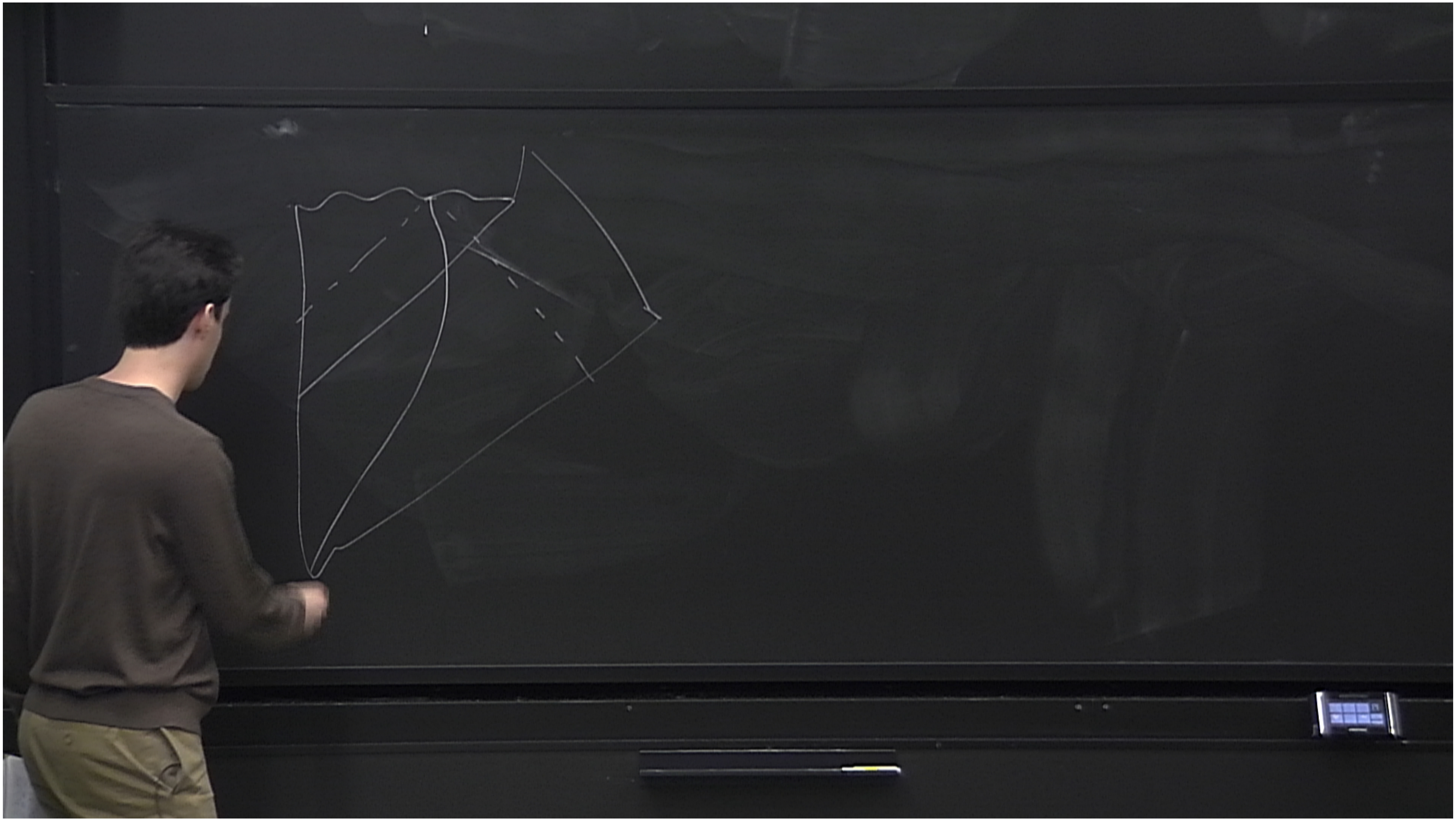
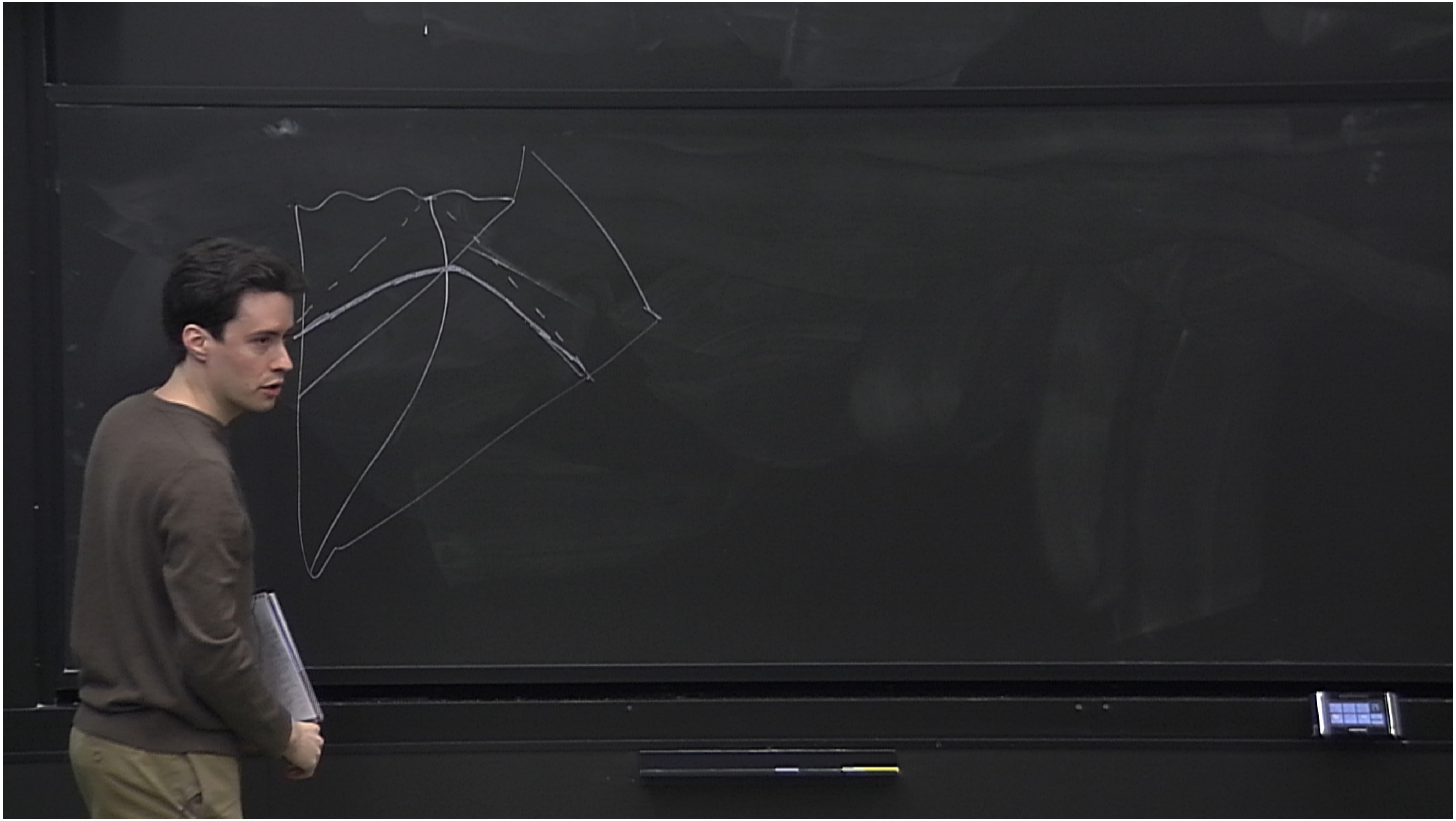
Title: Quantum Computation vs. Firewalls

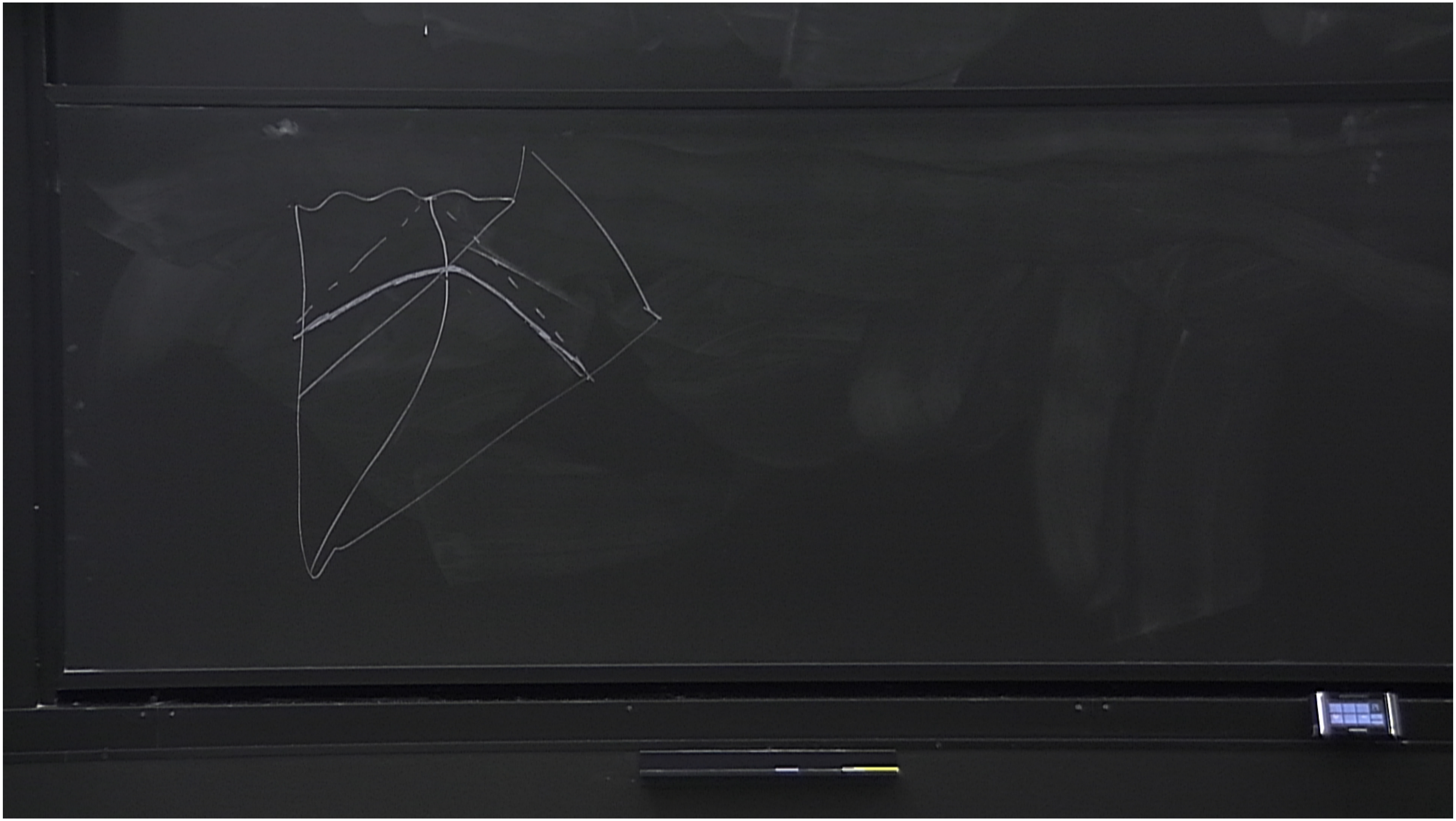
Date: Feb 26, 2013 02:00 PM

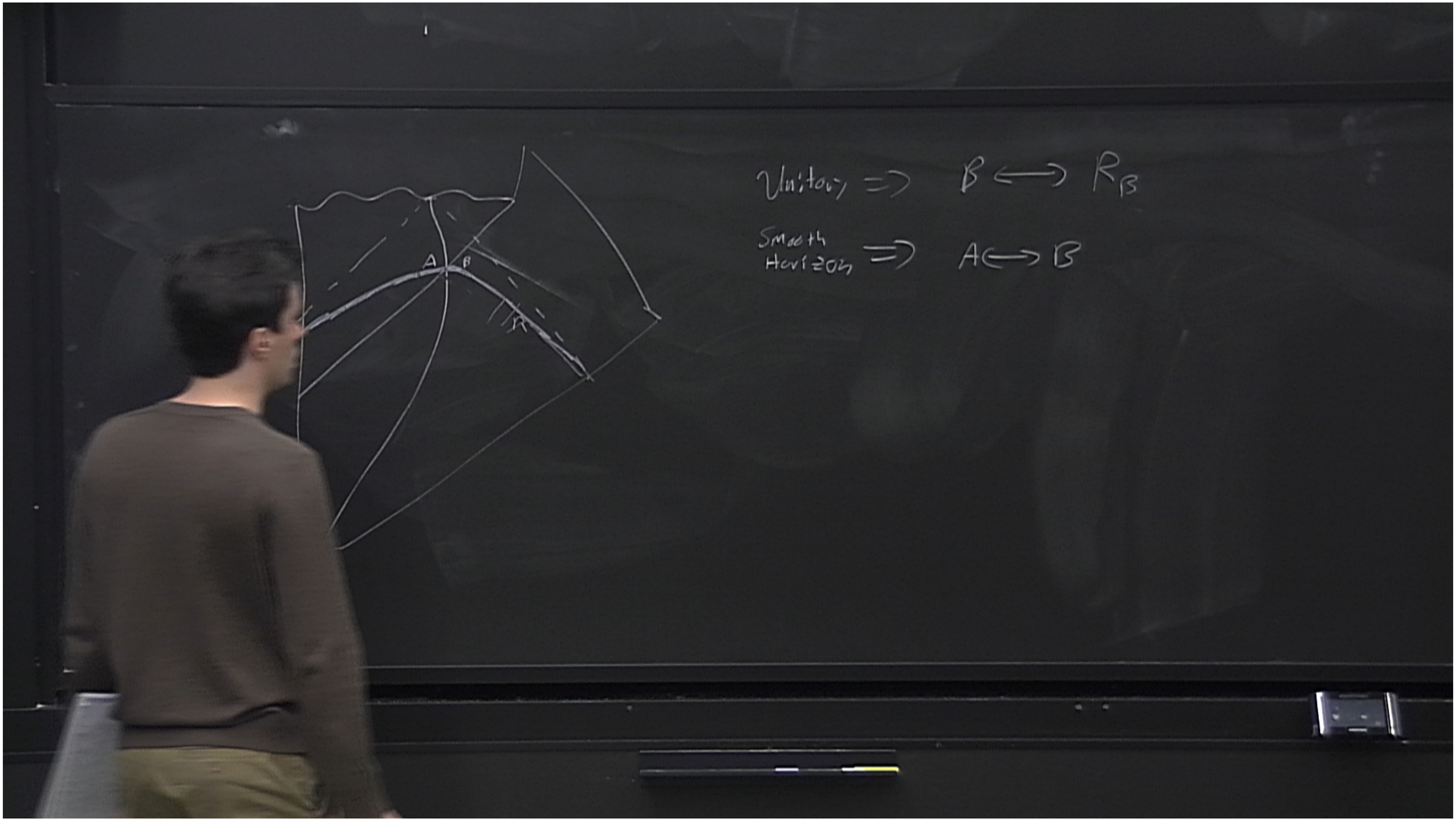
URL: http://www.pirsa.org/13020138

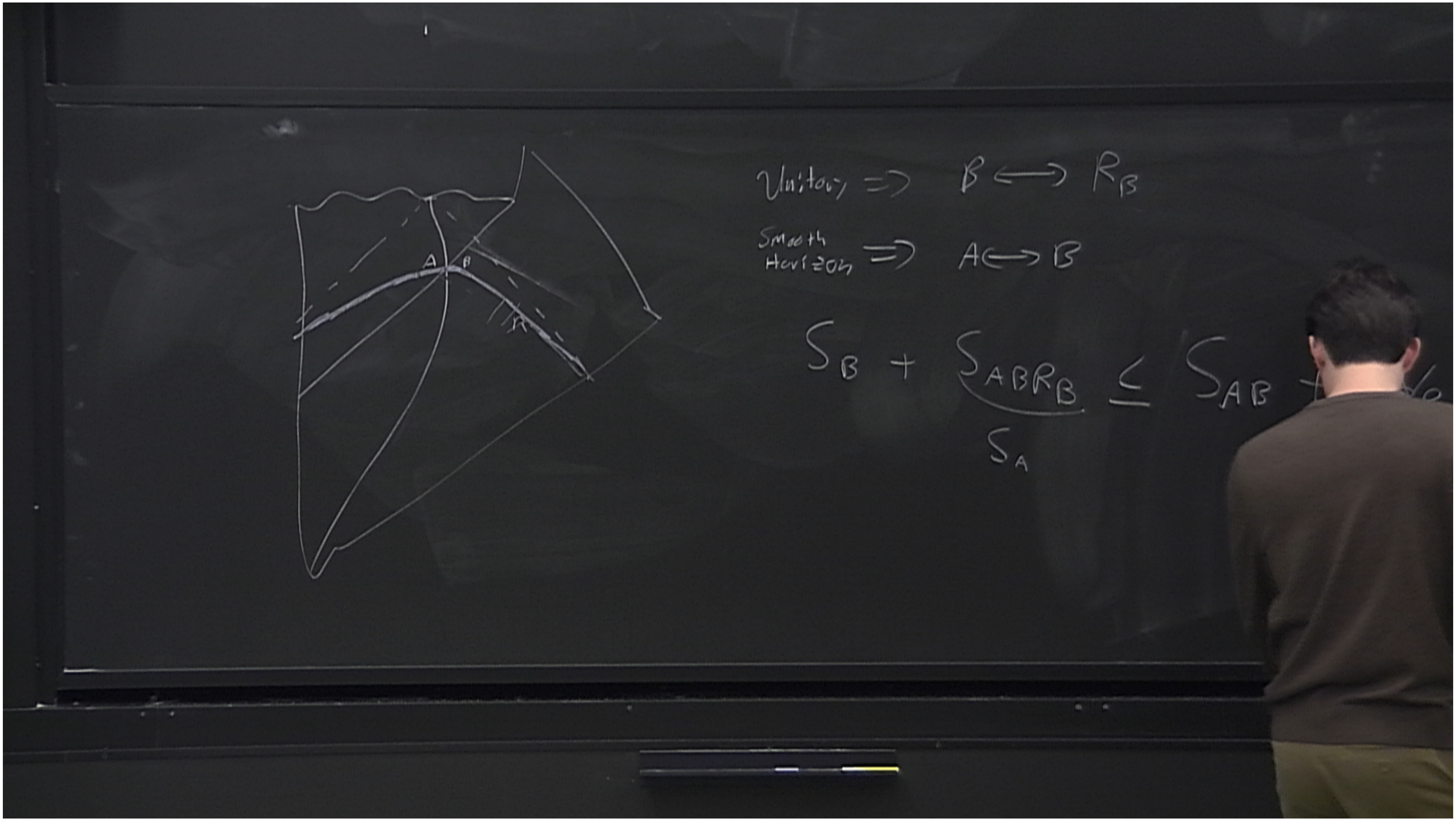
Abstract:



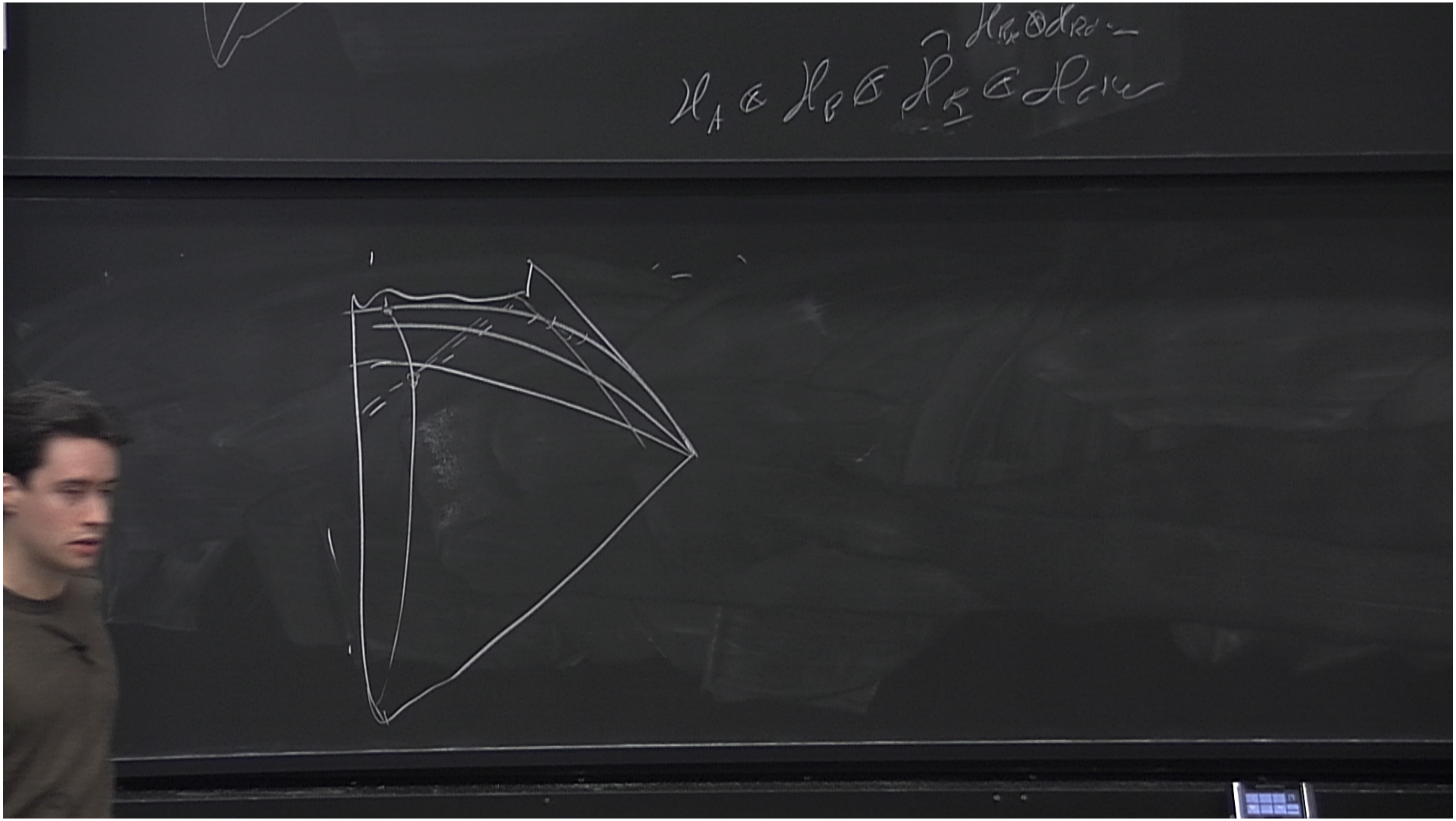


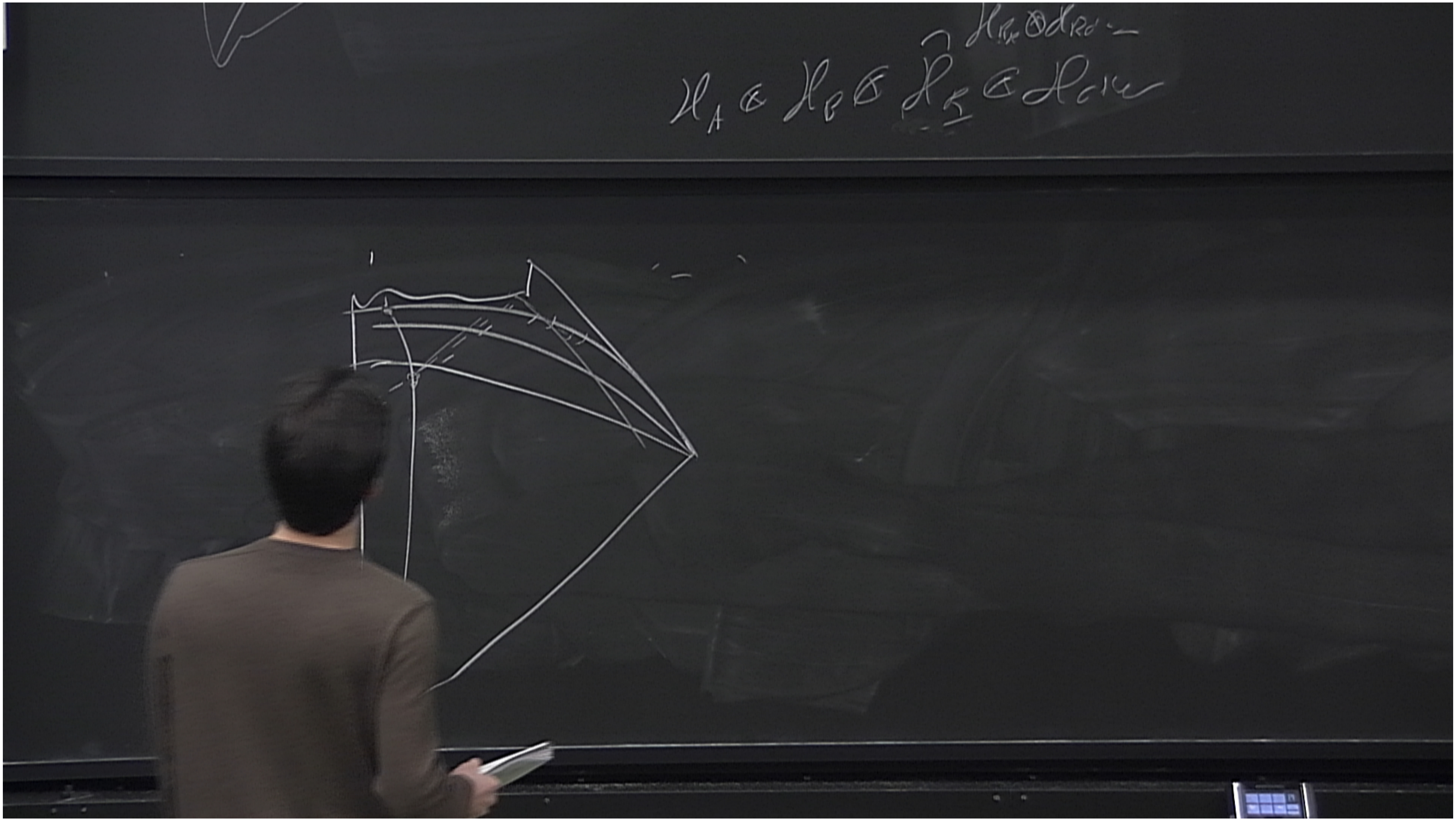



A
B
R
Unitary ⟹ B ⟷ R_B
Smooth Horizon ⟹ A ⟷ B



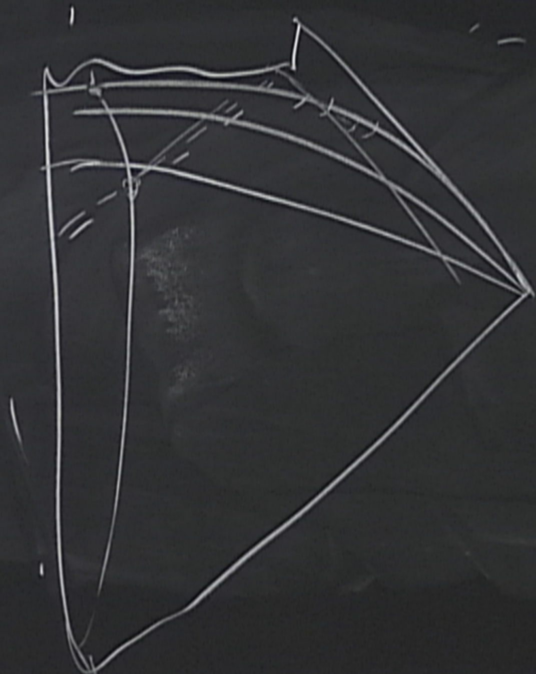
A
B
Unitary ⇒ B ⟷ R_B
Smooth Horizon ⇒ A ⟷ B
S_B + S_ABR_B ≤ S_AB
S_A





$\supset \mathcal{H}_{R_H} \otimes \mathcal{H}_{Rd} \cdots$

$\mathcal{H}_A \otimes \mathcal{H}_B \otimes \mathcal{H}_{\underline{R}} \otimes \mathcal{H}_{else}$

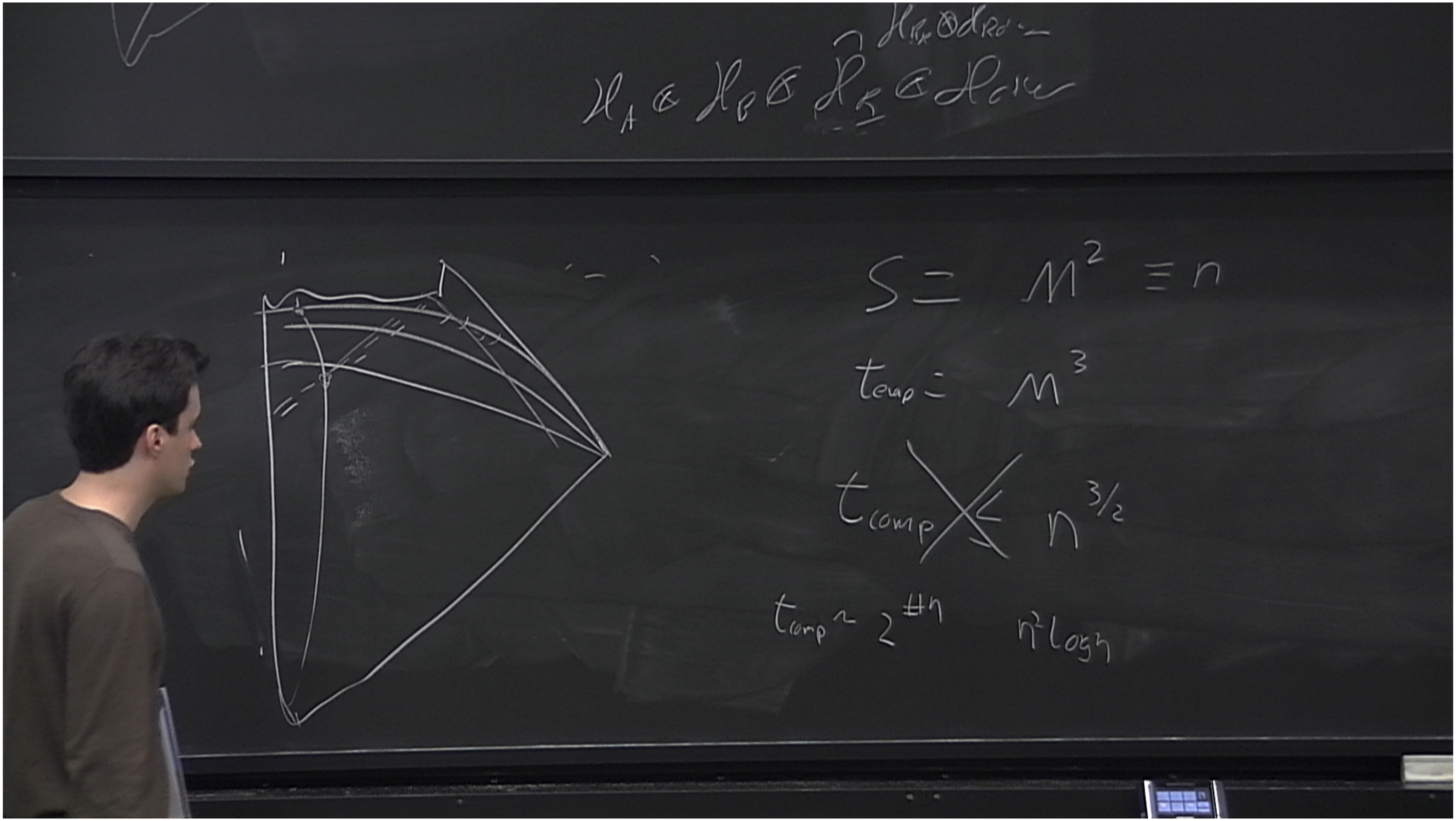


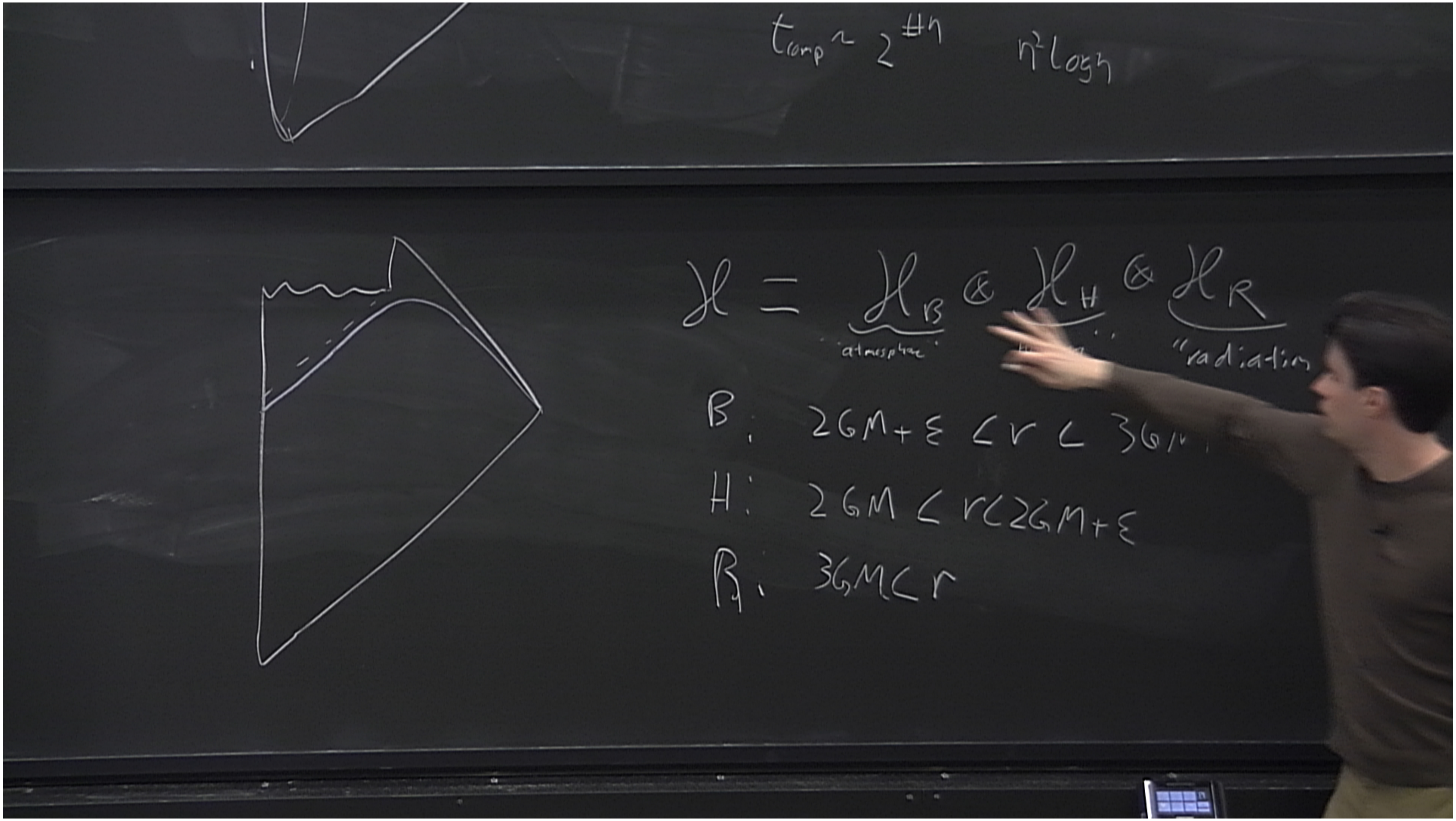
$S = M^2 \equiv n$

$t_{evap} = M^3$

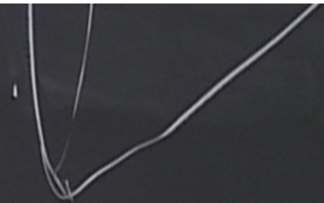
$t_{comp} \leq n^{3/2}$

$n^2 \log n$

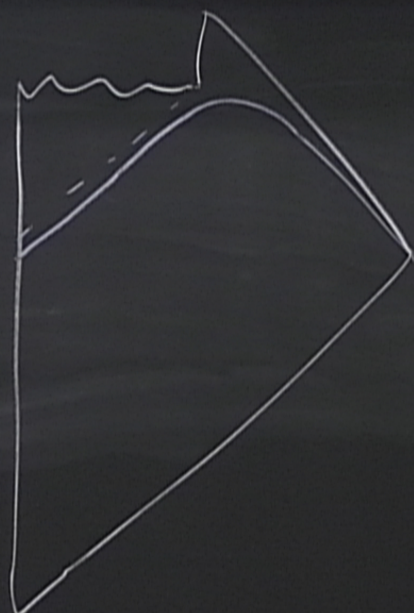

S = M² ≡ n
t_evap = M³
t_comp < n^{3/2}
t_comp ~ 2^{#n}
n² log n



$t_{comp} \sim 2^{\# n}$
$n^2 \log n$
$\mathcal{H} = \mathcal{H}_B \otimes \mathcal{H}_H \otimes \mathcal{H}_R$
"atmosphere"
"radiati
B: $2GM + \varepsilon < r < 3G$
H: $2GM < r < 2GM + \varepsilon$
R: $3GM < r$



$t_{comp} \sim 2^{\# n}$ $\quad n^2 \log n$

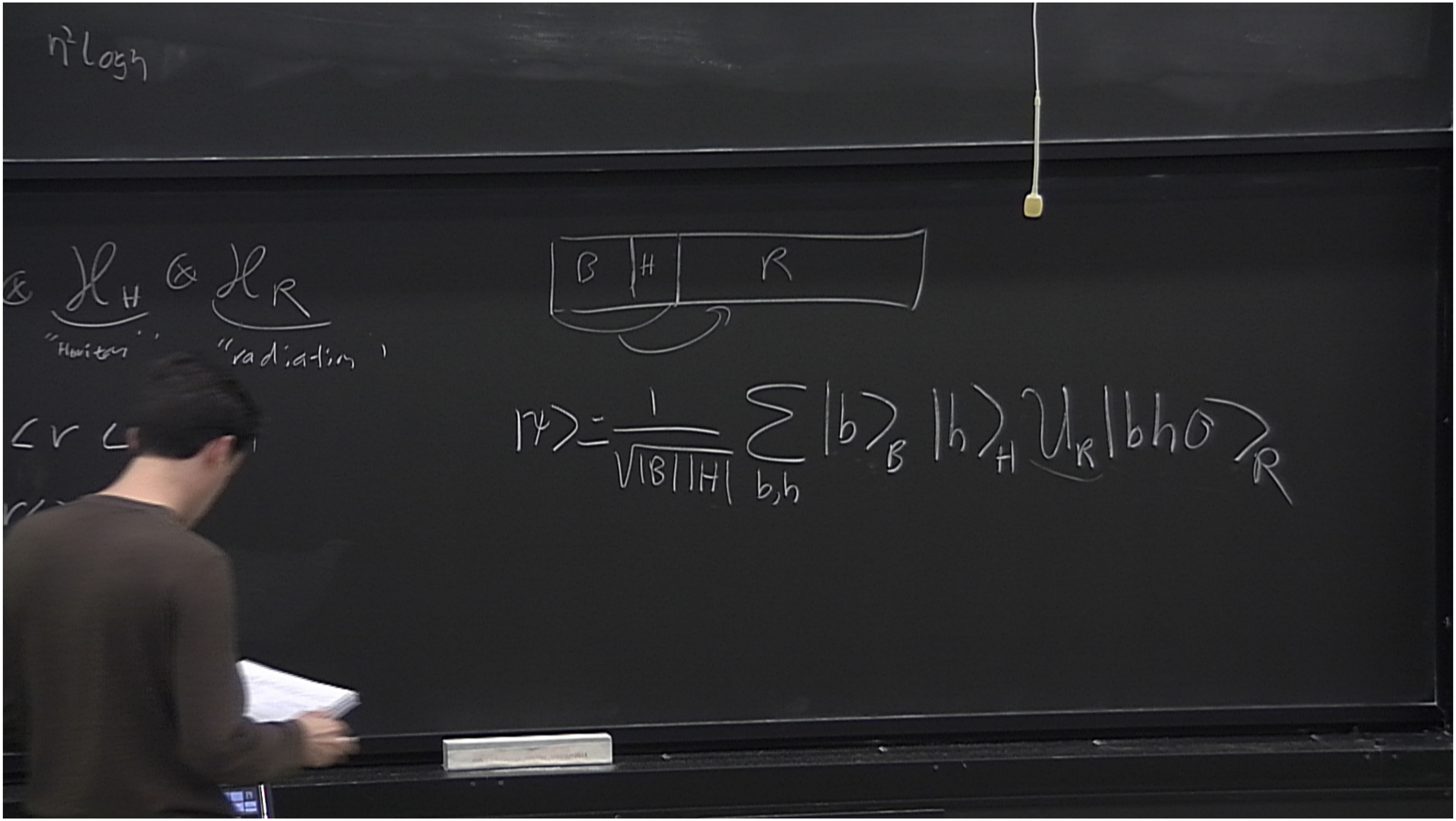


$$\mathcal{H} = \underbrace{\mathcal{H}_B}_{\text{"atmosphere"}} \otimes \underbrace{\mathcal{H}_H}_{\text{"Horizon"}} \otimes \underbrace{\mathcal{H}_R}_{\text{"radiation"}}$$

B: $2GM + \varepsilon < r < 3GM$

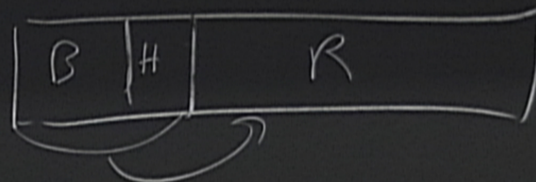
H: $2GM < r < 2GM + \varepsilon$

R: $3GM < r$


n² log n
⊗ ℋ_H ⊗ ℋ_R
"Horizon" "radiation"
B H R
|ψ⟩ = 1/√(|B||H|) Σ_{b,h} |b⟩_B |h⟩_H U_R |bh0⟩_R

$n^2 \log n$

$\otimes \underbrace{\mathcal{H}_H}_{\text{"Horizon"}} \otimes \underbrace{\mathcal{H}_R}_{\text{"radiation"}}$

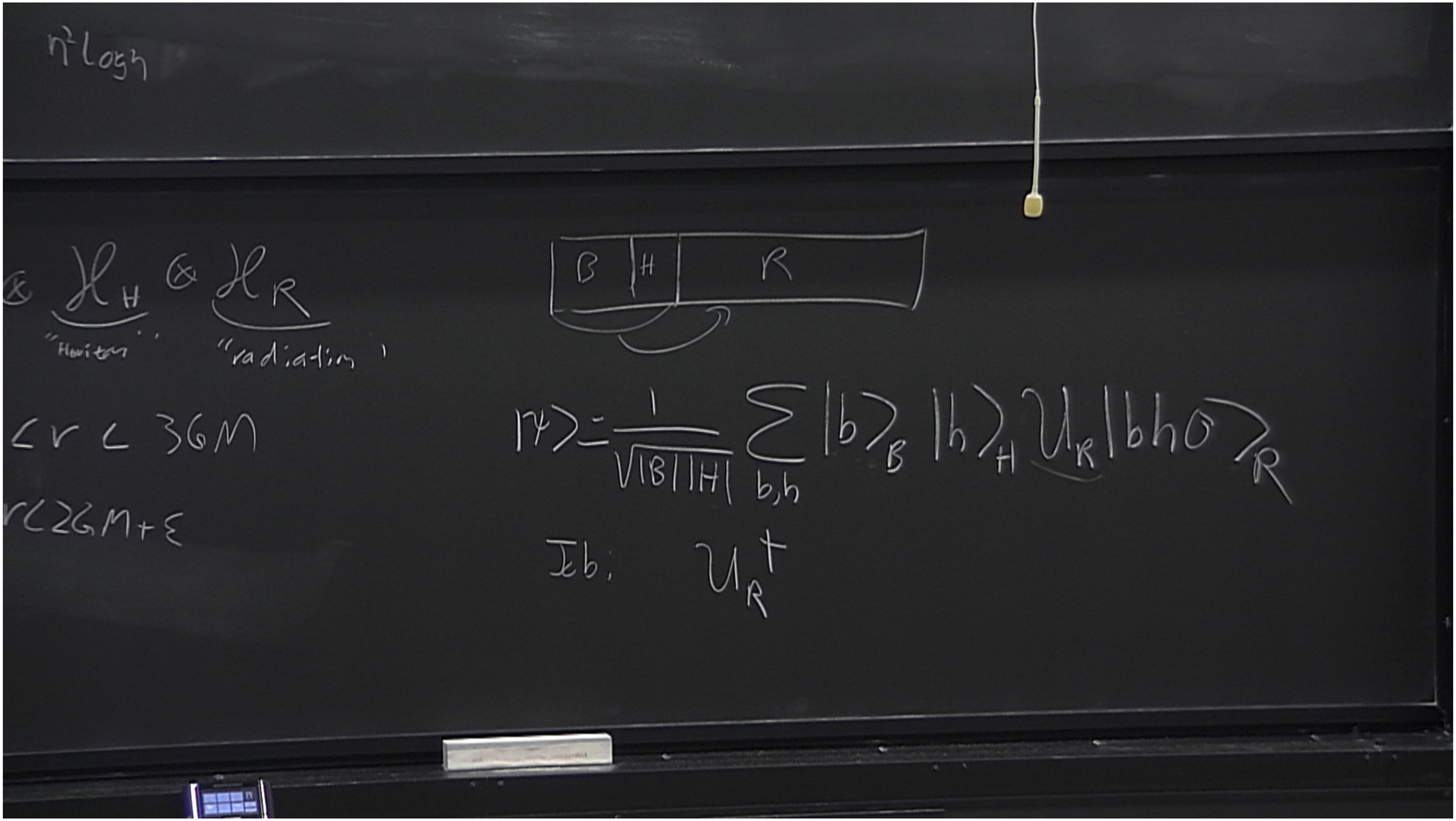


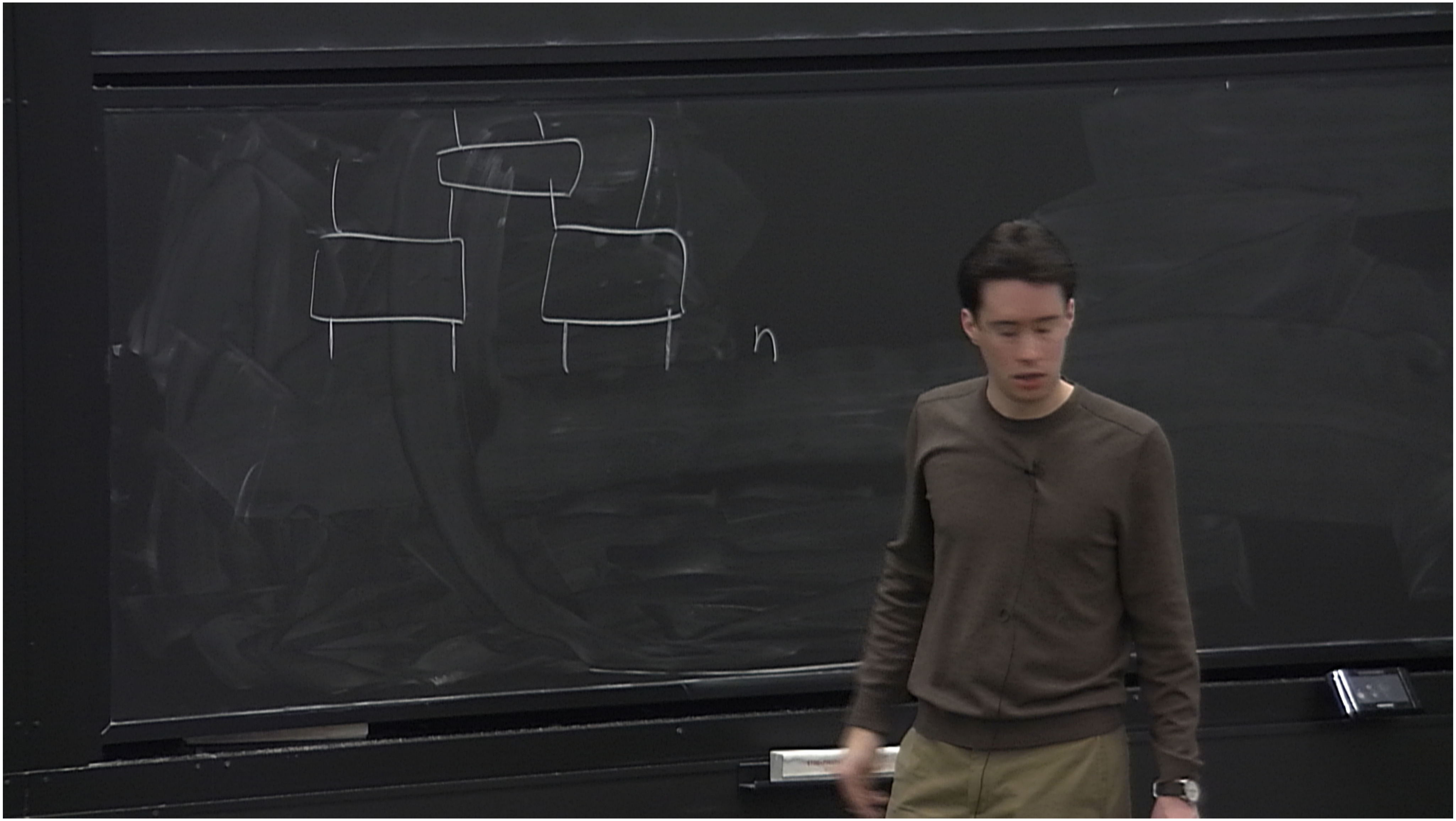
$< r < 3GM$

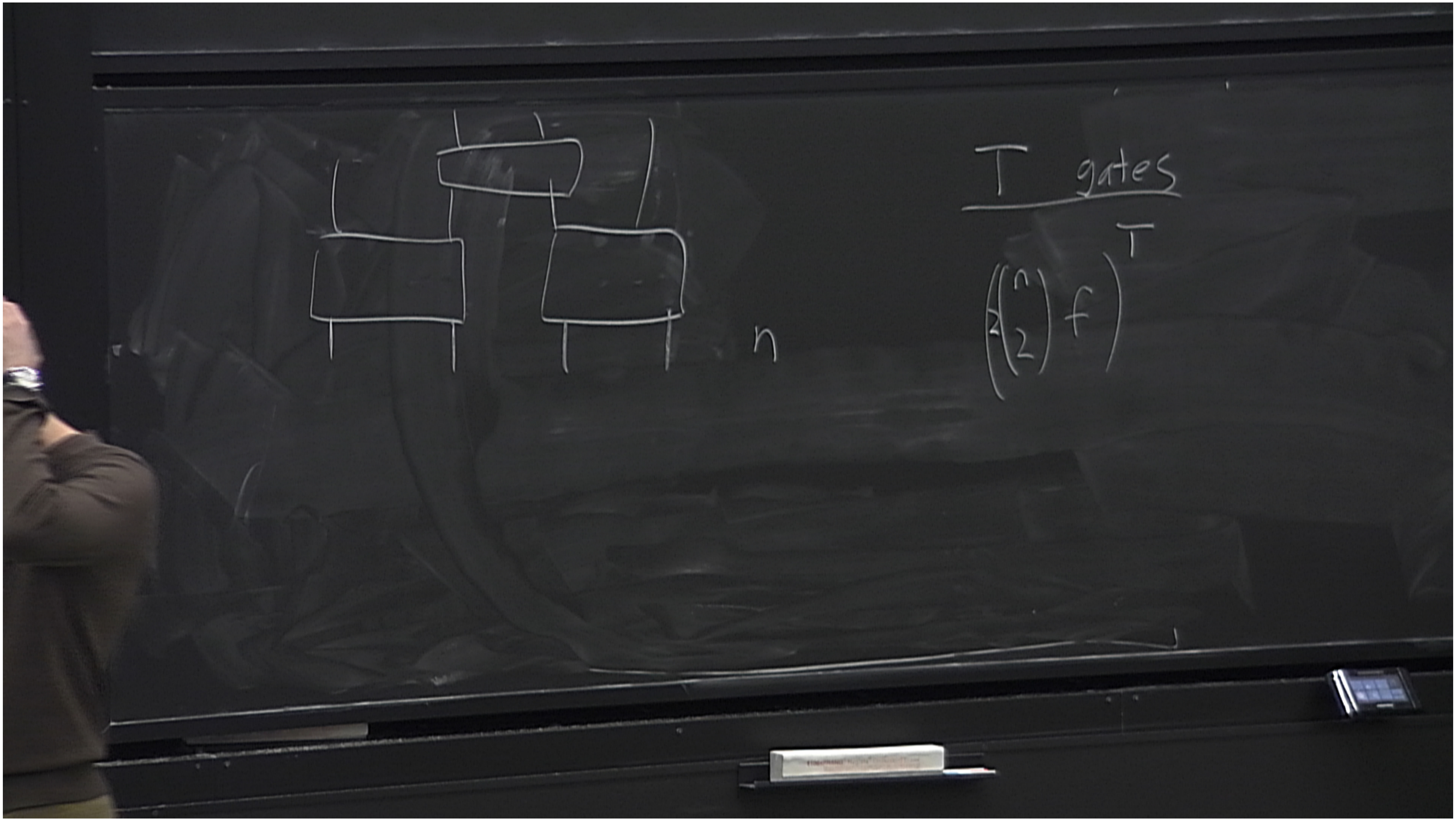
$r < 2GM + \varepsilon$

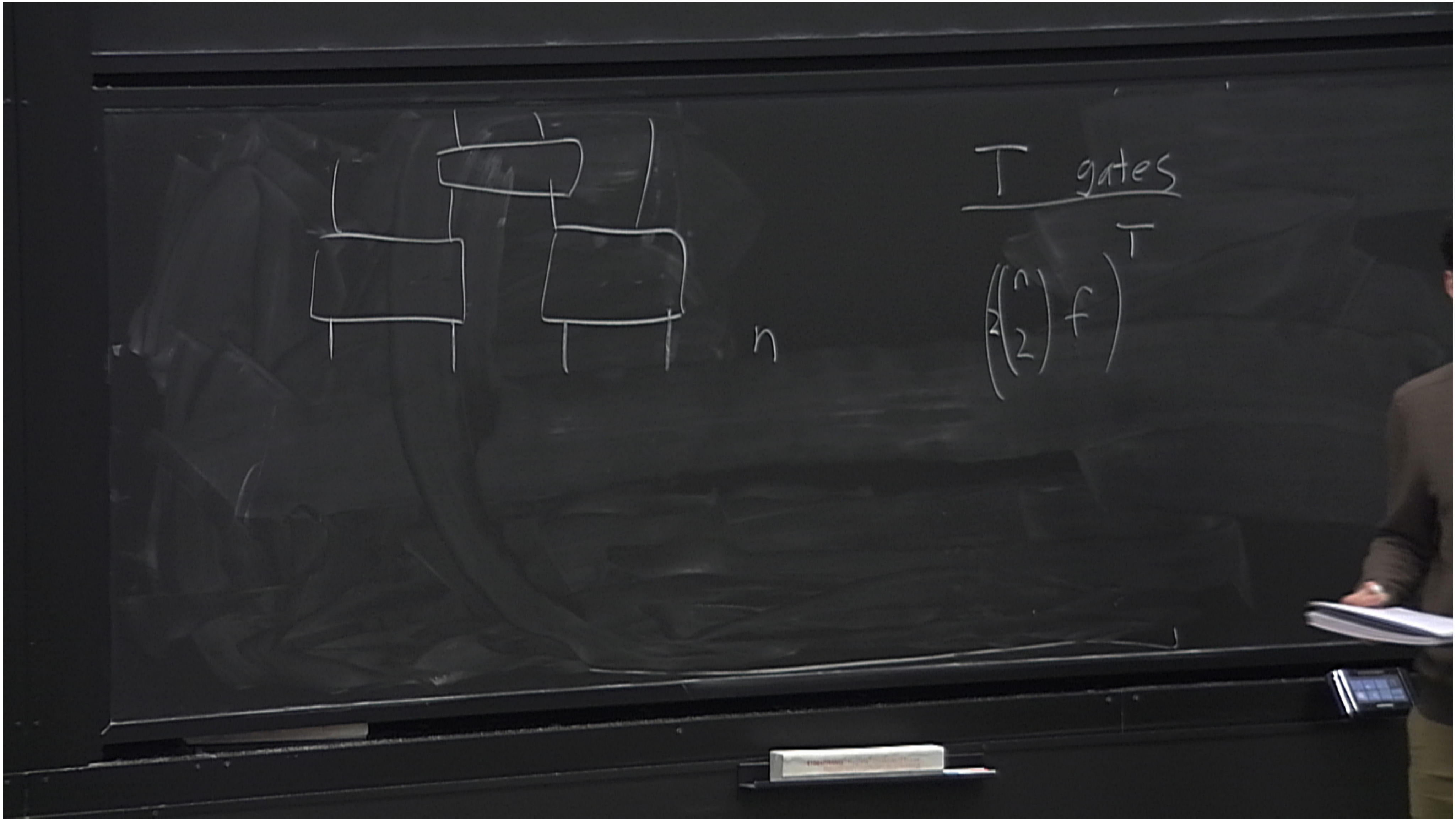
$$|\psi\rangle = \frac{1}{\sqrt{|B||H|}} \sum_{b,h} |b\rangle_B \, |h\rangle_H \, \underbrace{U_R}\, |bh0\rangle_R$$

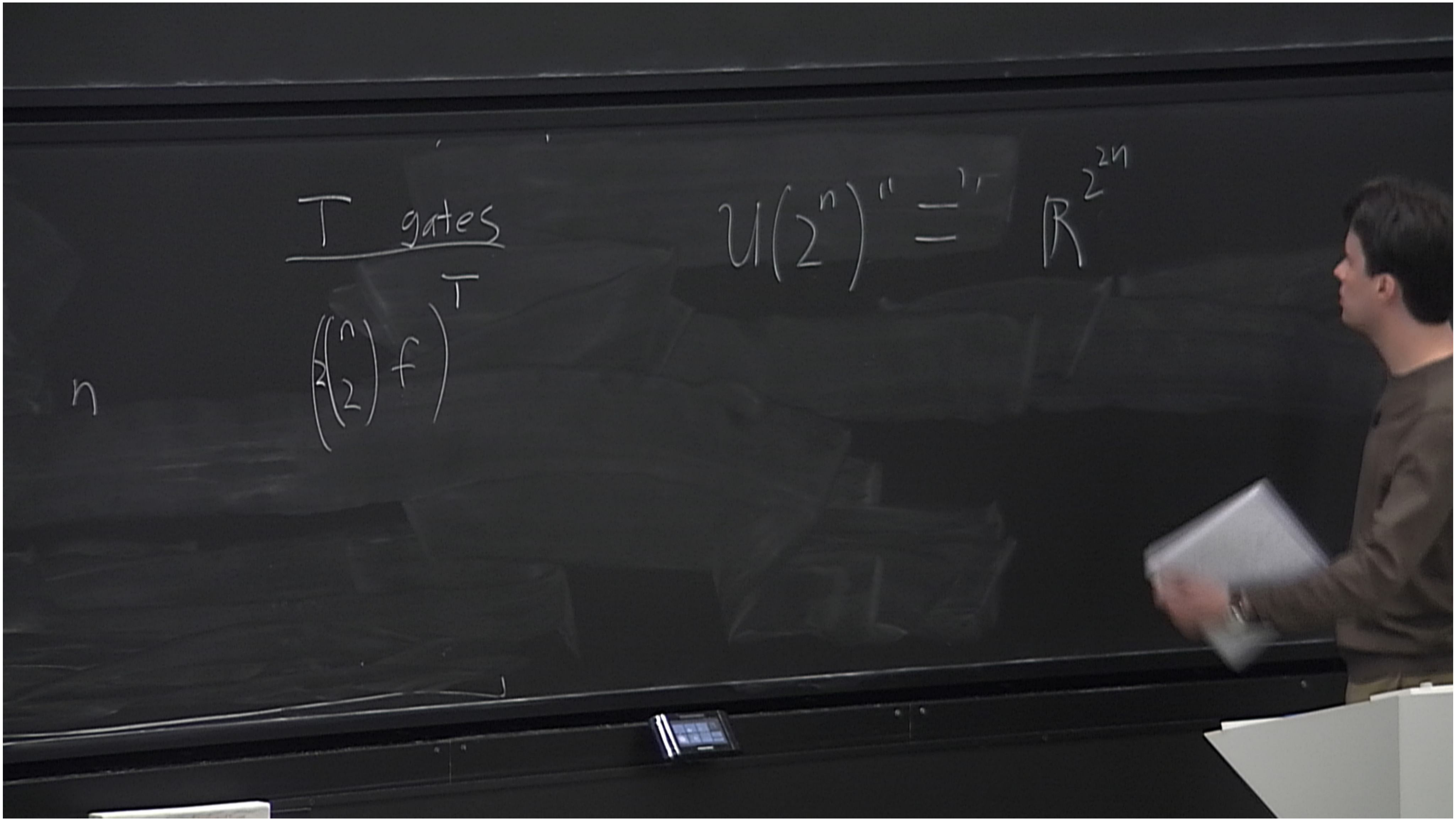
Σb: $U_R^{\dagger}$

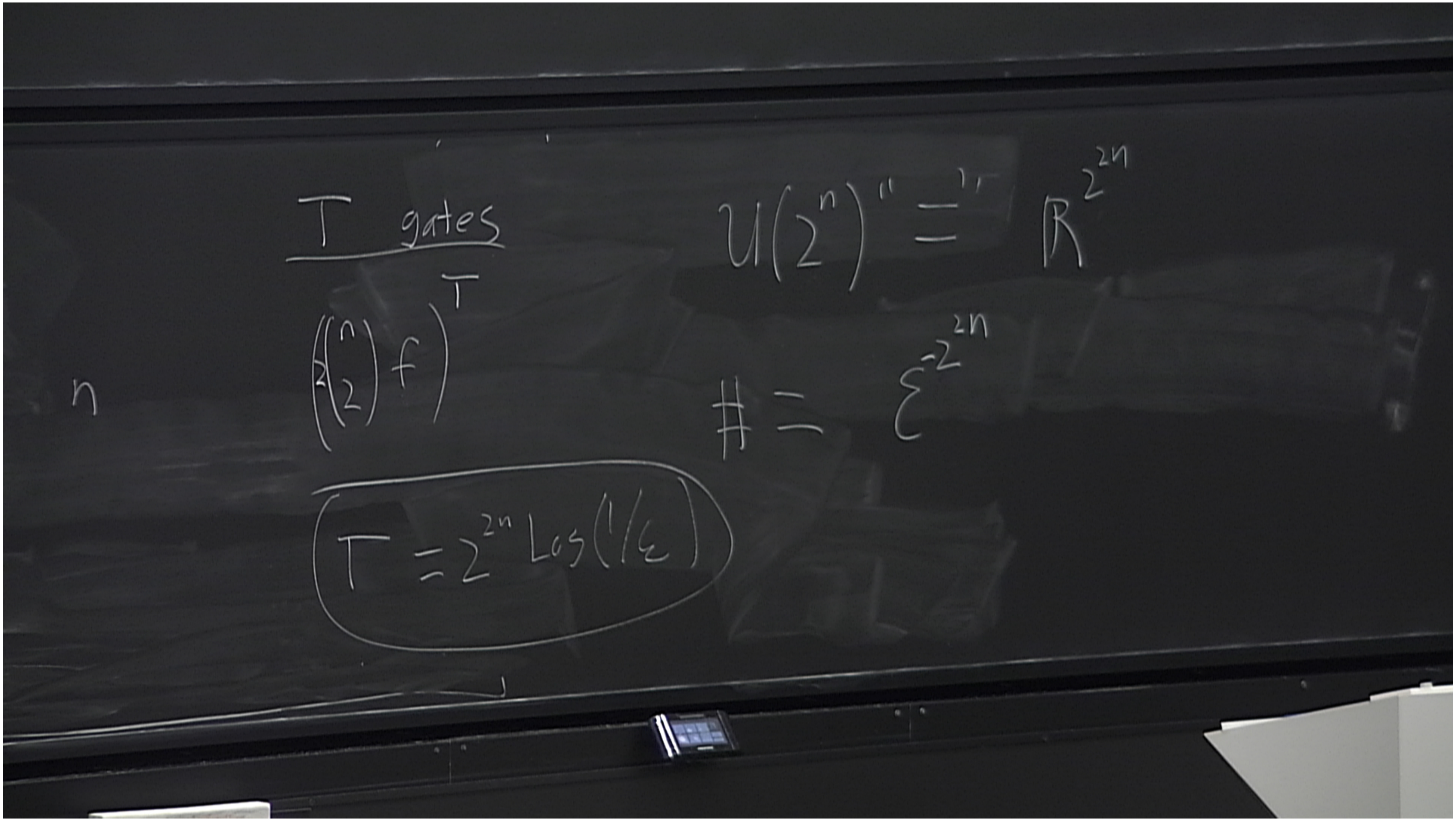

n²log n
⊗ ℋ_H ⊗ ℋ_R
"Horizon"
"radiation"
< r < 3GM
r < 2GM + ε
B
H
R
|ψ⟩ = 1/√(|B||H|) Σ_{b,h} |b⟩_B |h⟩_H U_R |bh0⟩_R
Ib: U_R^†

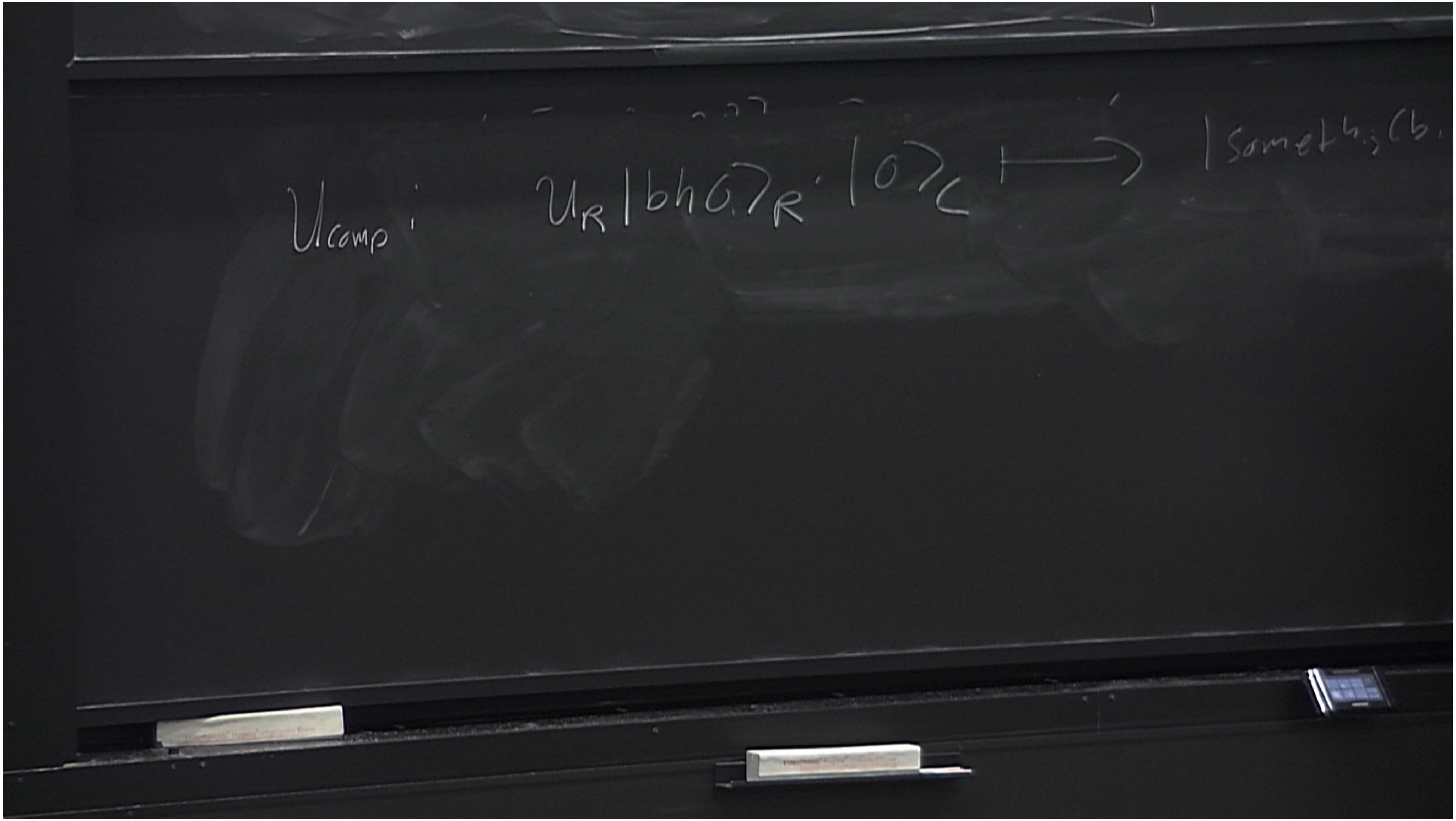

n


T gates
n
$\left(2\binom{n}{2} f\right)^T$

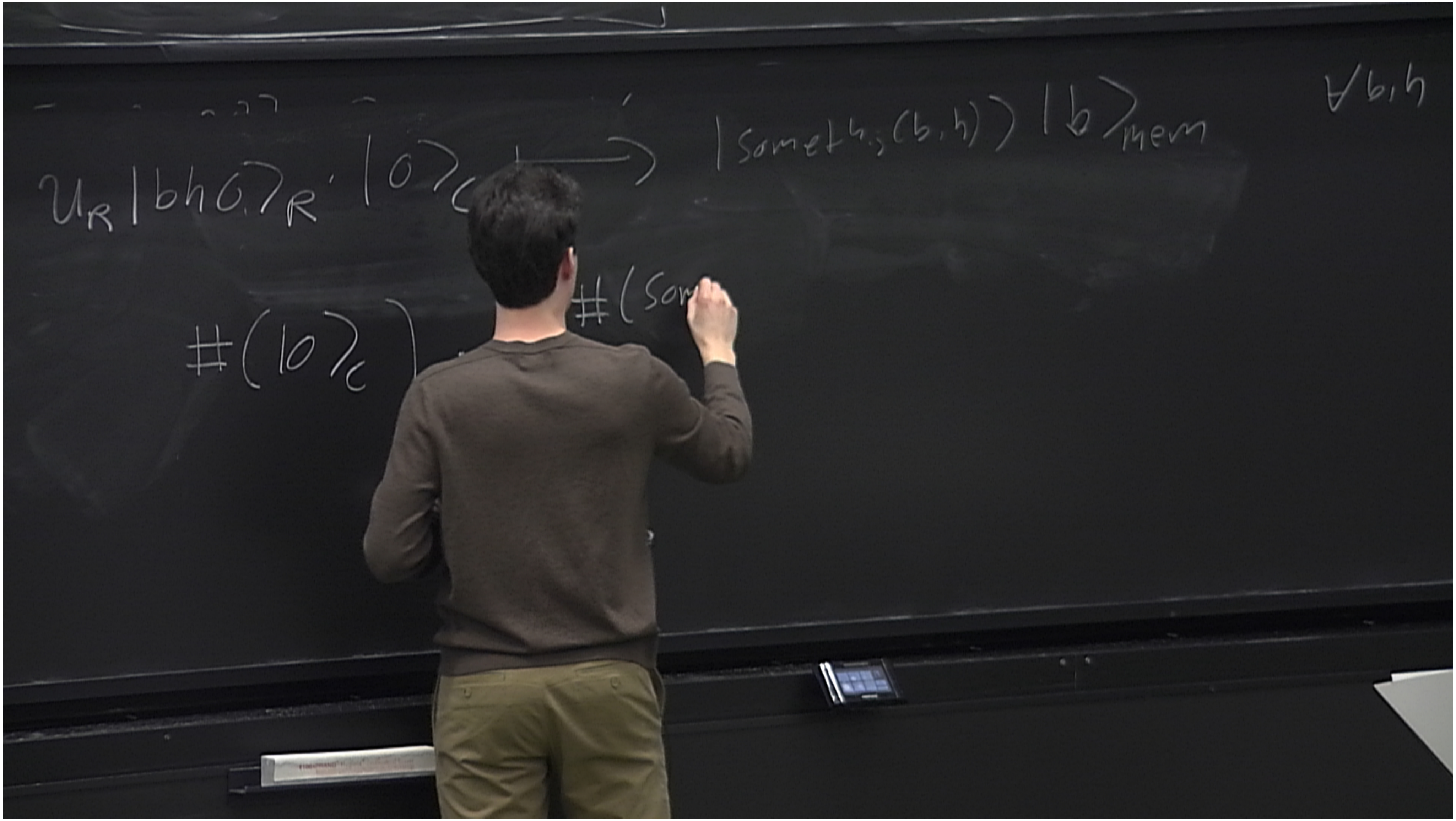

T gates
n
f

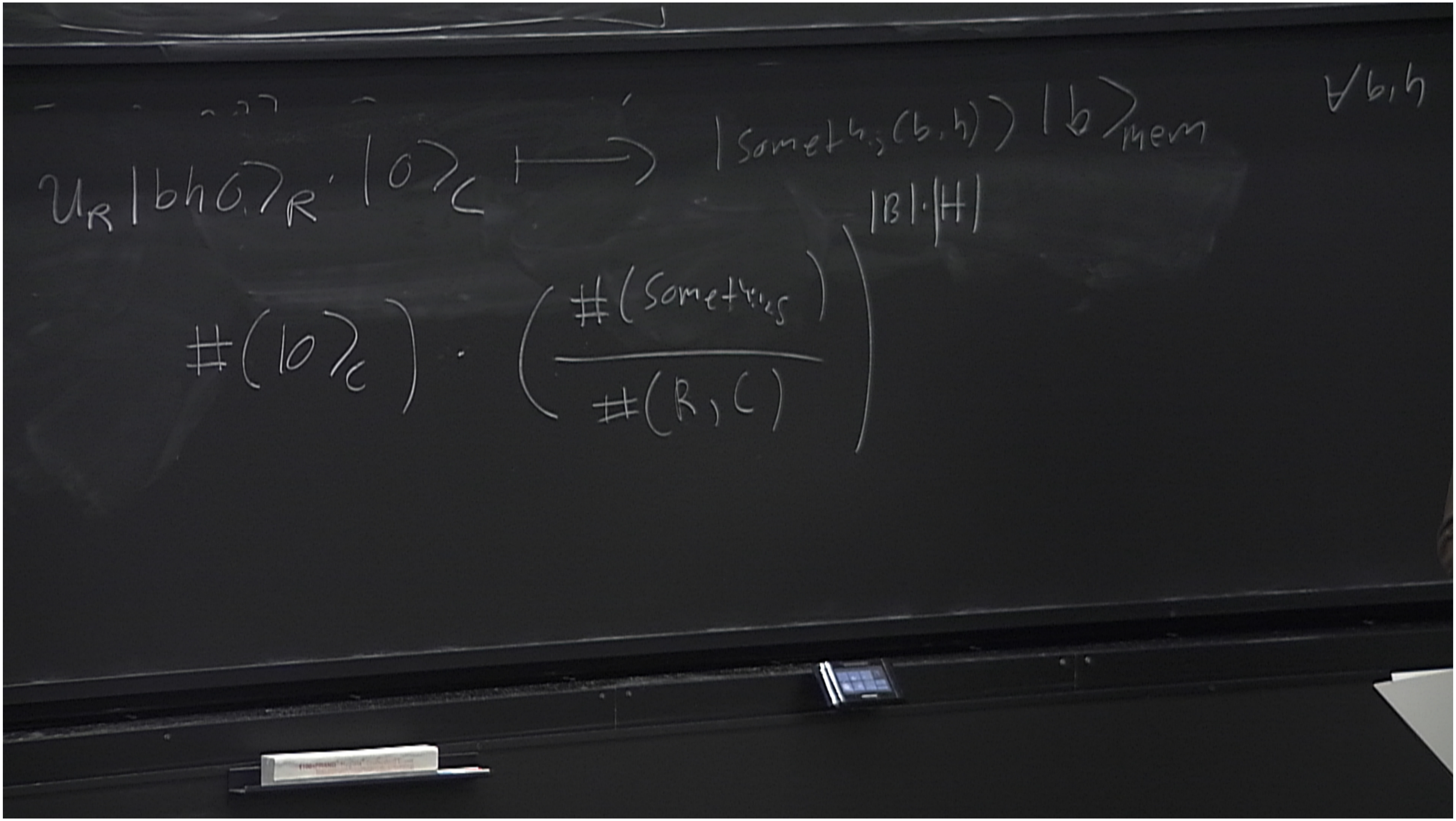

T gates
$U(2^n)$ "=" $\mathbb{R}^{2^{2n}}$
$\left(2\binom{n}{2} f\right)^T$
n

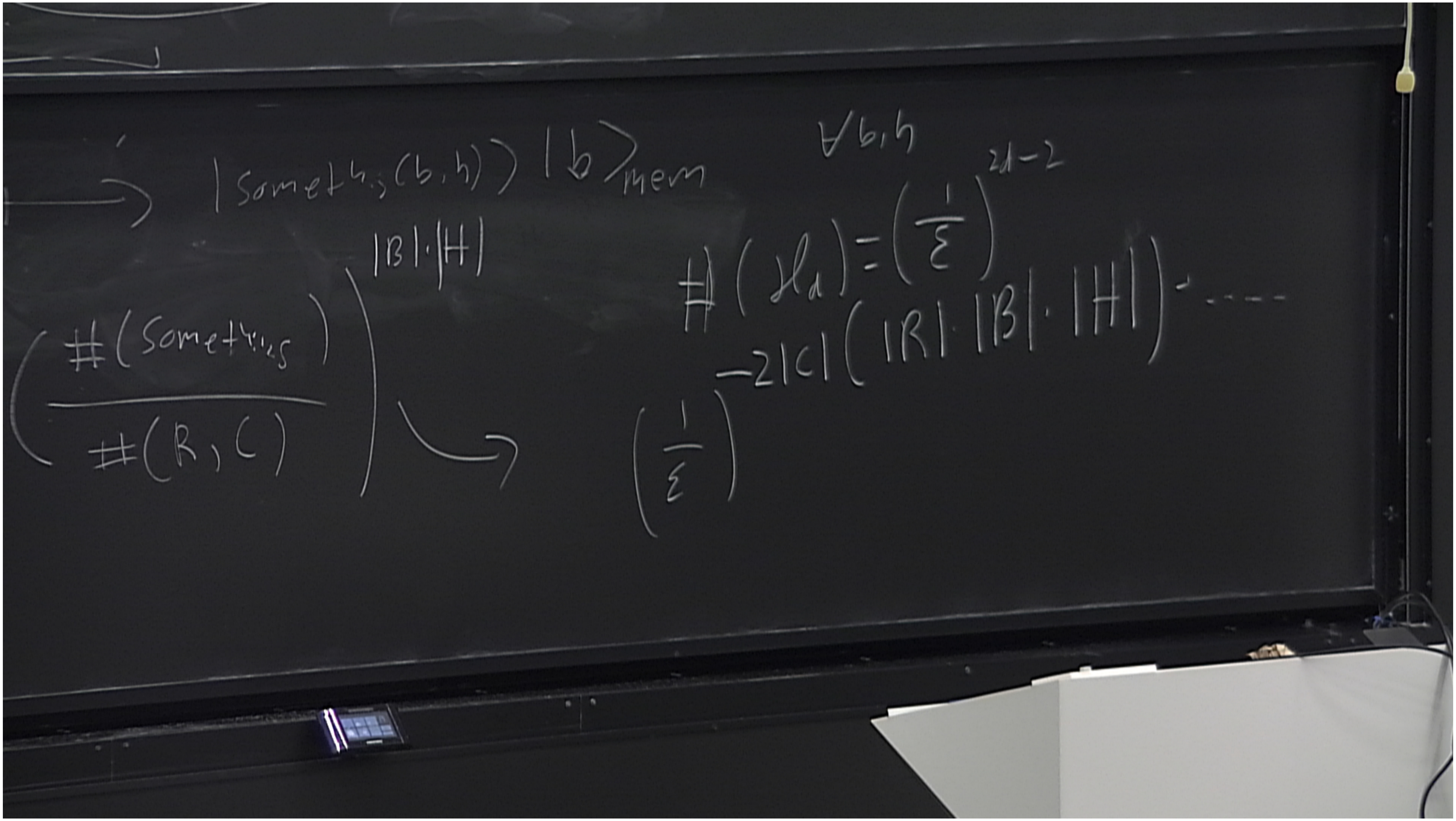

T gates
n
$\left(2\binom{n}{2} f\right)^T$
$U(2^n)$ "=" $\mathbb{R}^{2^{2n}}$
$\# = \varepsilon^{-2^{2n}}$
$T = 2^{2n} \log(1/\varepsilon)$


U_{comp} : $U_R |bh(t)\rangle_R \cdot |0\rangle_L \mapsto |\text{something}(b$

$$U_R |bh0\rangle_R \cdot |0\rangle_C \longmapsto |\text{somethi}(b,h)\rangle |b\rangle_{mem}$$

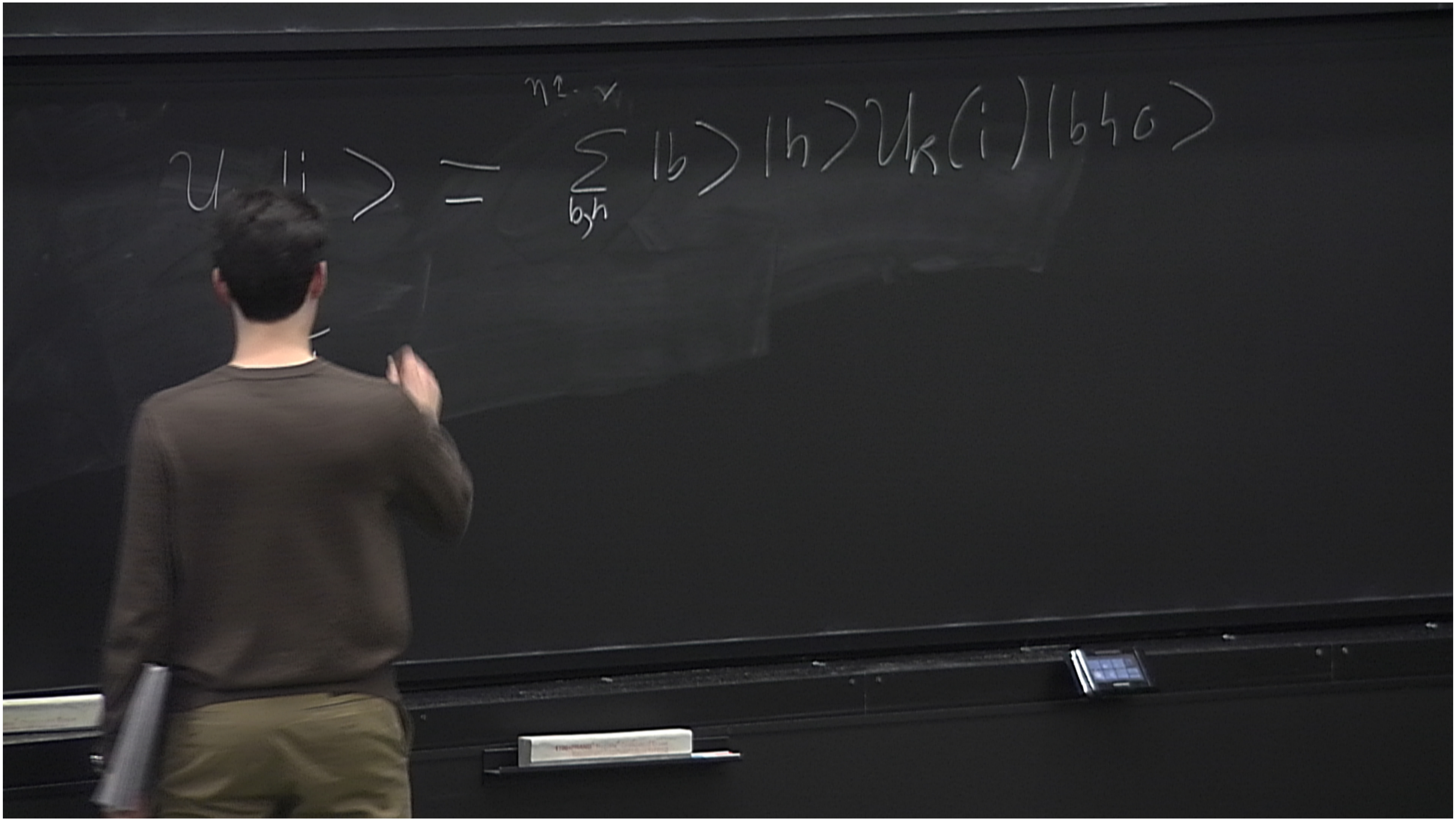

∀b,h
|something(b,h)⟩ |b⟩mem
UR |bh0⟩R' |0⟩C
#(|0⟩C)
#(som

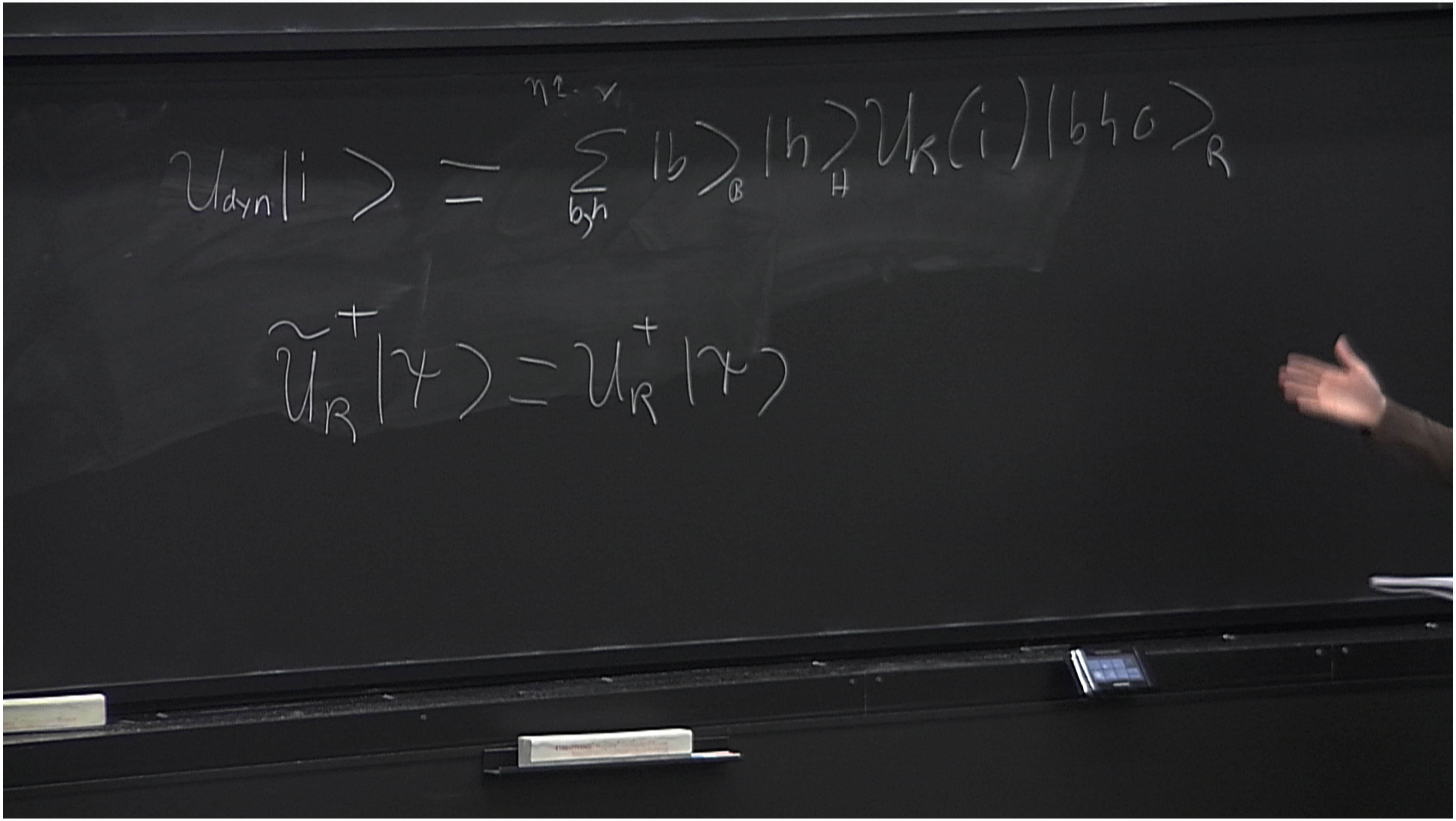

U_R |bh0⟩_R · |0⟩_C ⟼ |something(b,h)⟩ |b⟩_mem
∀ b, h
#(|0⟩_C) · (#(something) / #(R, C))^{|B|·|H|}



$\longrightarrow |\text{something}(b,h)\rangle\, |b\rangle_{mem}$ $\forall b,h$
$\left(\frac{\#(\text{something})}{\#(B,C)}\right)^{|B|\cdot|H|}$
$\#(\mathcal{H}_d) = \left(\frac{1}{\varepsilon}\right)^{2d-2}$
$\left(\frac{1}{\varepsilon}\right)^{-2|C|(|R|\cdot|B|\cdot|H|)} + \cdots$

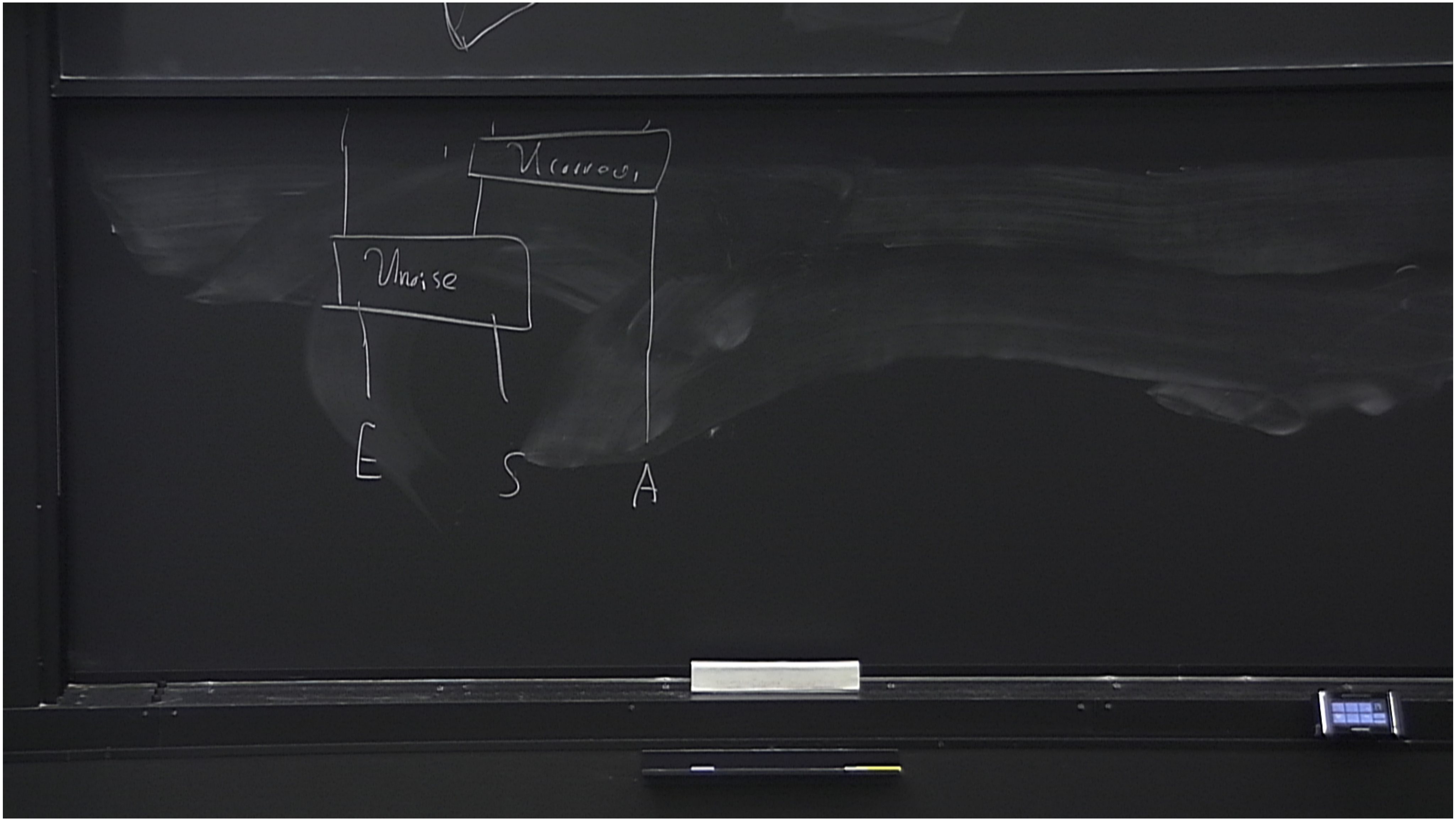
$$\mathcal{U}_{dyn}|i\rangle = \sum_{b,h}^{n_1 \cdots r} |b\rangle |h\rangle \mathcal{U}_k(i) |b h o\rangle$$




$U_{dyn}|i\rangle = \sum_{b,h}^{n^2 \cdot \gamma} |b\rangle_B |h\rangle_H U_R(i)|bh0\rangle_R$
$\tilde{U}_R^{\dagger}|\psi\rangle = U_R^{\dagger}|\psi\rangle$

$$\mathcal{U}_{dyn}|i\rangle = \sum_{b,h}^{n^2 \cdot N} |b\rangle_B |h\rangle_H \, \mathcal{U}_R(i)|bh0\rangle_R$$

$$\tilde{\mathcal{U}}_R^\dagger |\psi\rangle = \mathcal{U}_R^\dagger |\psi\rangle$$


Unoise
E
S
A

1) Given U_{noise}, is there a U_{corr}?

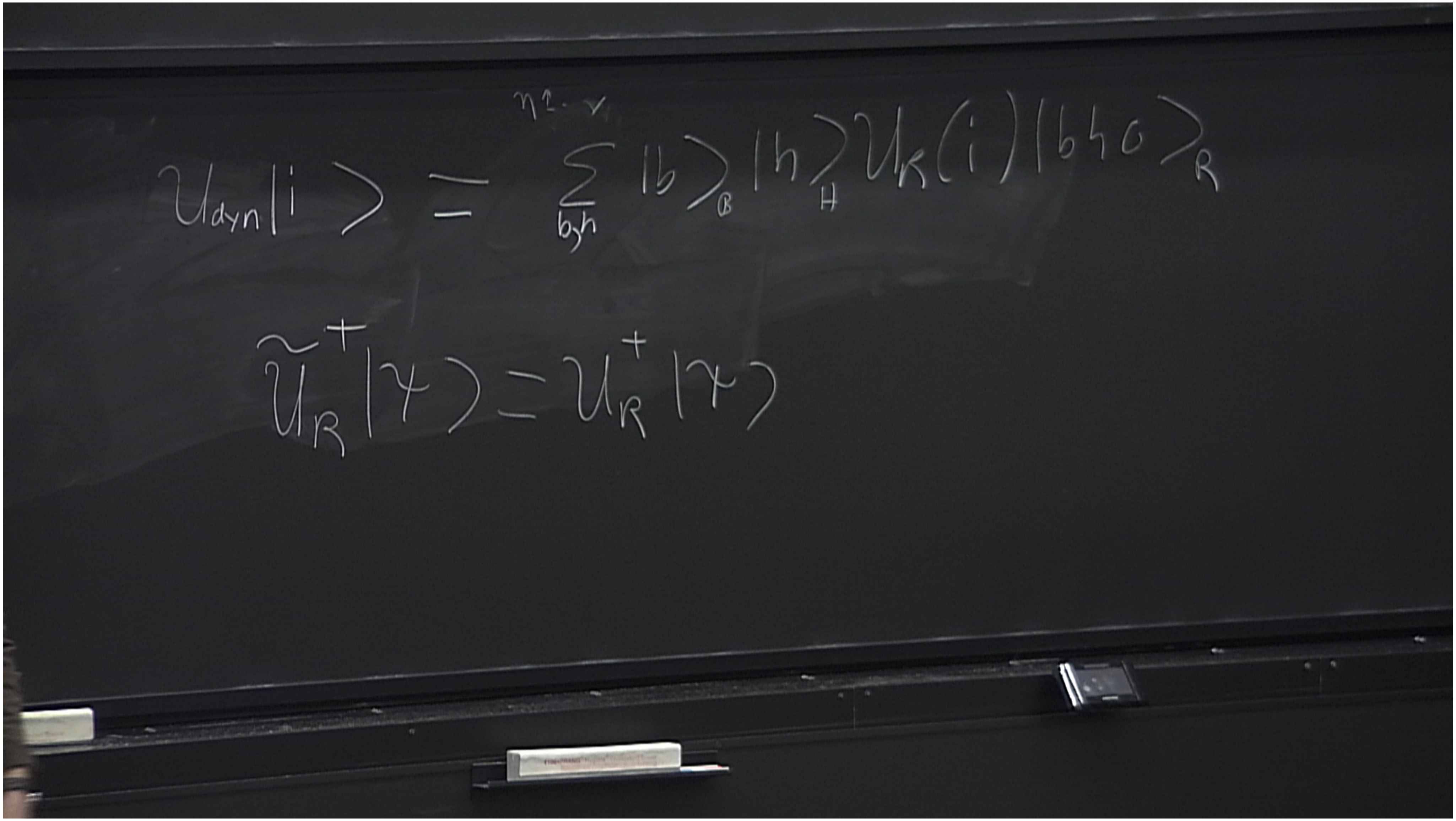
2) Given correctability, how hard is it?

$\#$ errs $\quad 2^{2n}$

$\#$ stab $\quad 2^{n-k}$

$$\frac{2^{2n}}{2^{n-k}} = 2^{n+k}$$

$2^{2k} \quad 2^{n-k}$


$\mathcal{U}_{dyn}|i\rangle = \sum_{b,h}^{n1\cdots N} |b\rangle_B |h\rangle_H \mathcal{U}_R(i)|bh0\rangle_R$
$\tilde{\mathcal{U}}_R^{\dagger}|\gamma\rangle = \mathcal{U}_R^{\dagger}|\gamma\rangle$