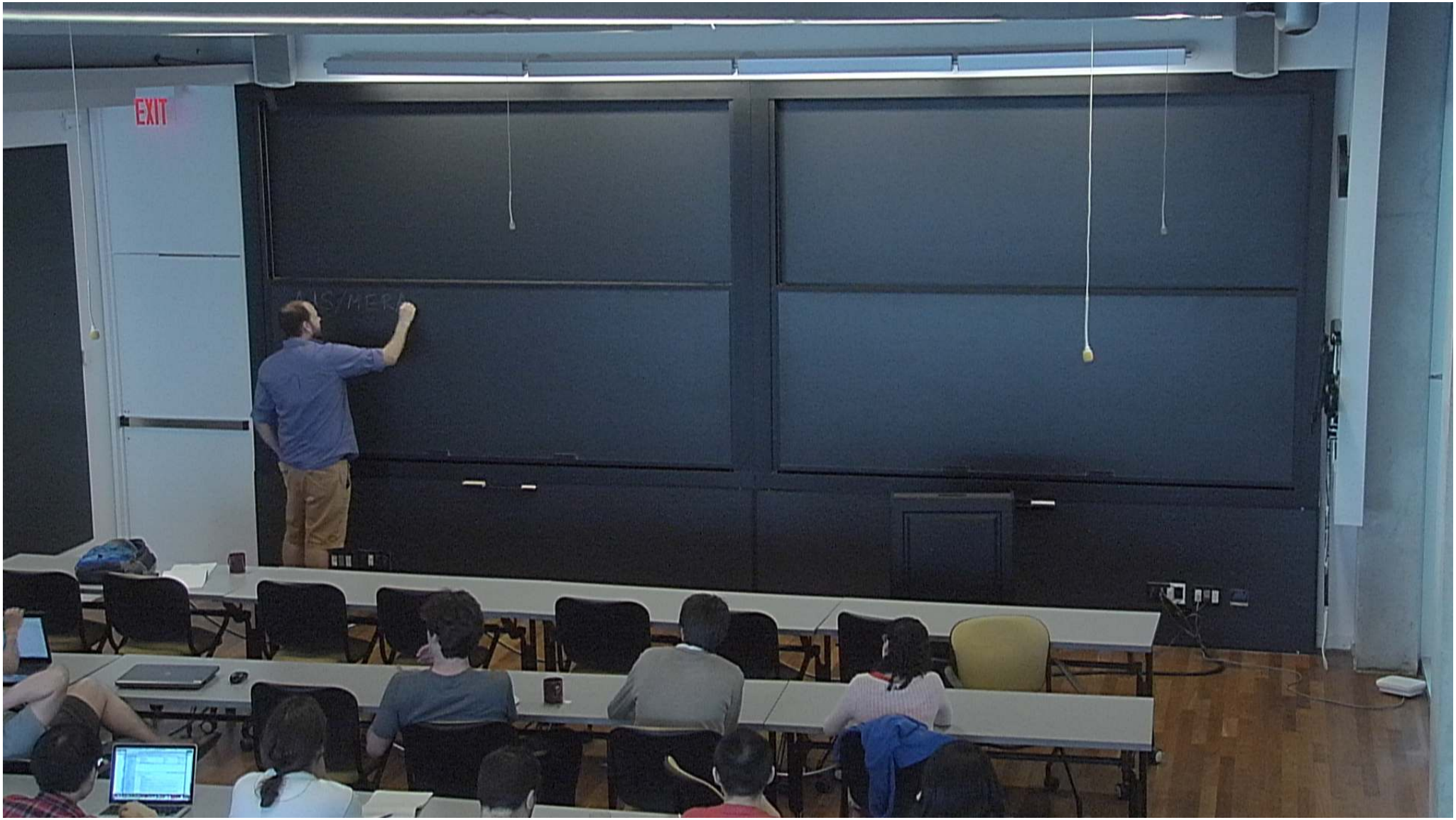
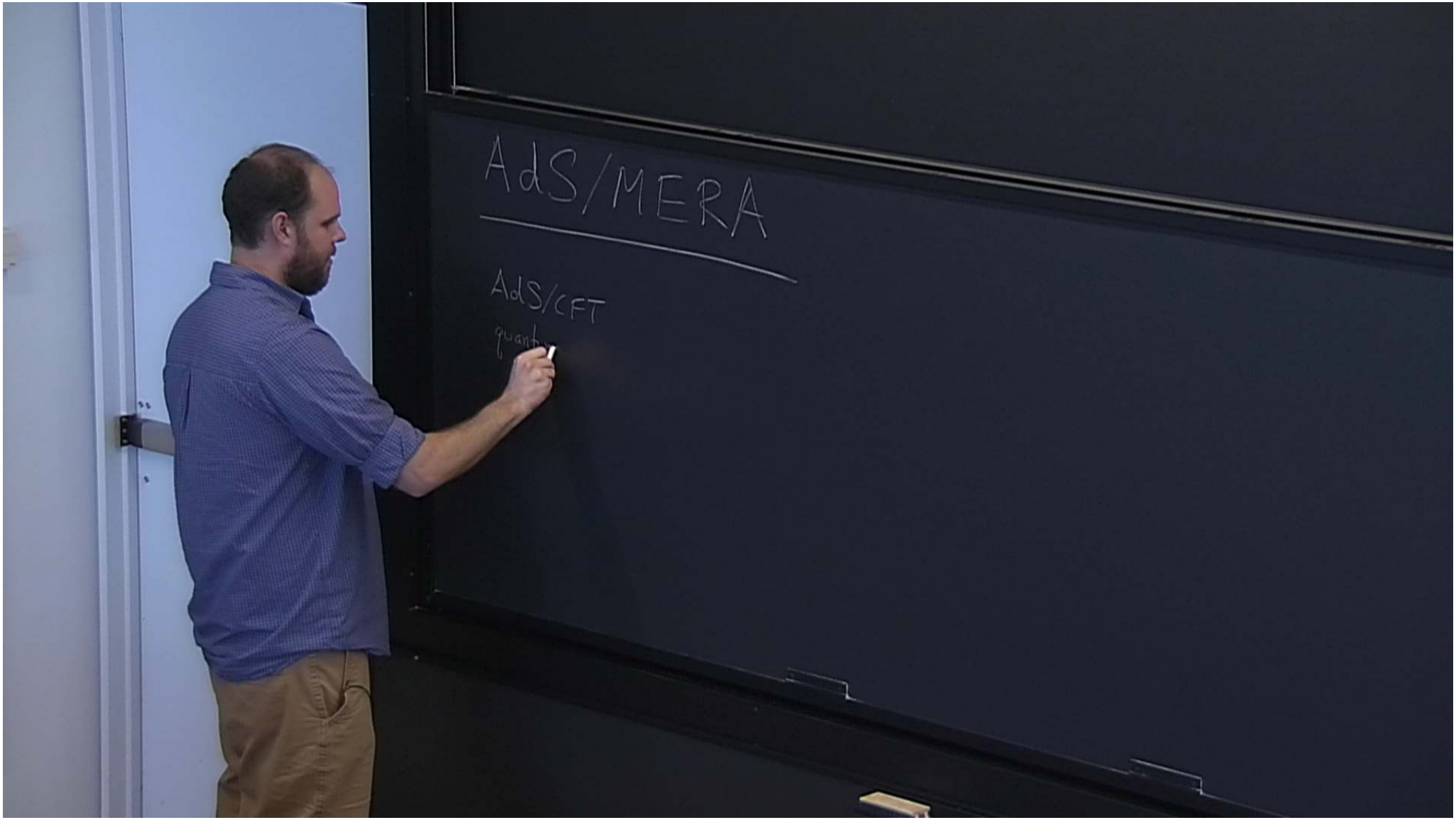
Title: PHD

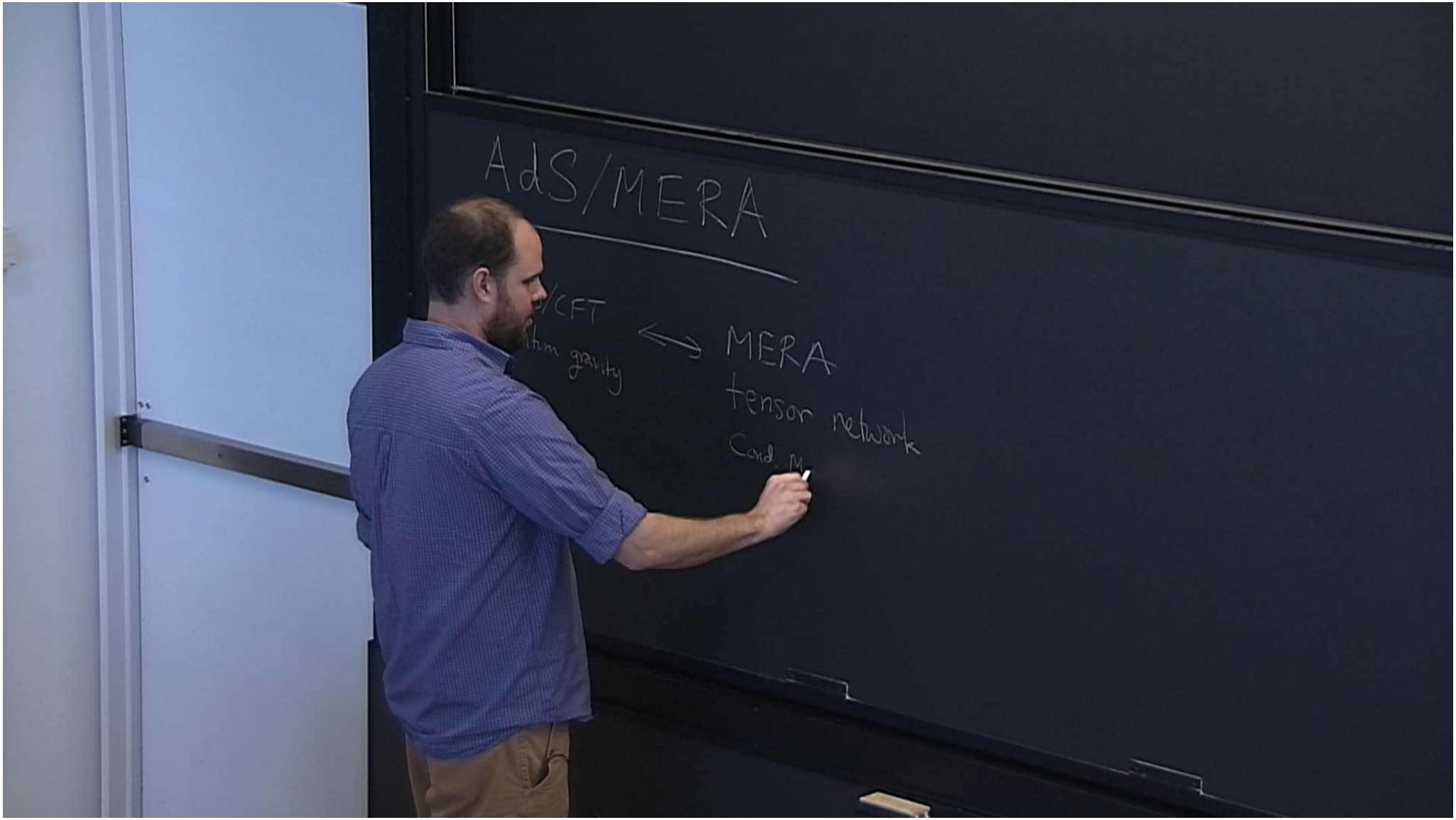
Date: May 28, 2014 04:30 PM

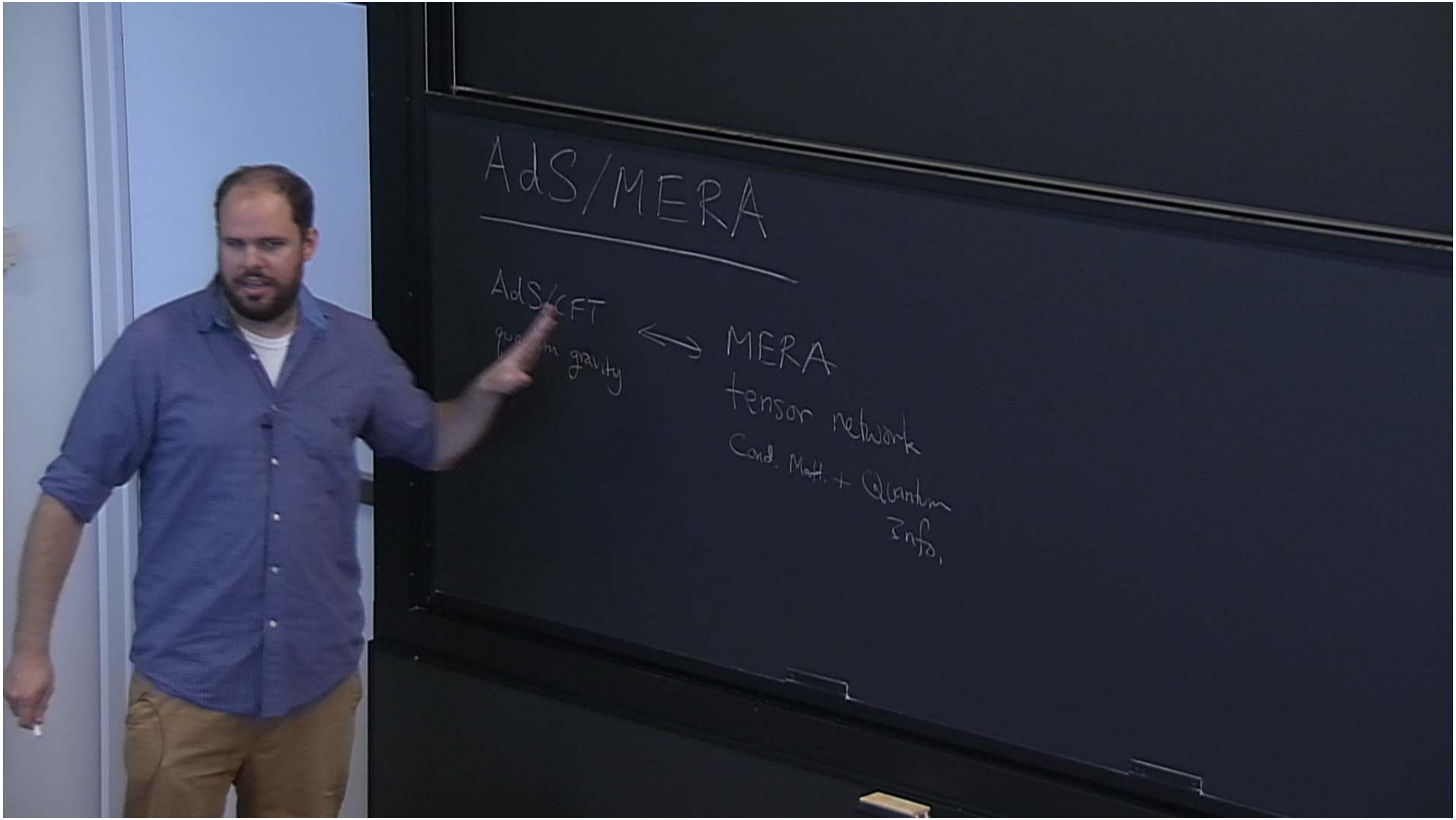
URL: http://pirsa.org/14050150

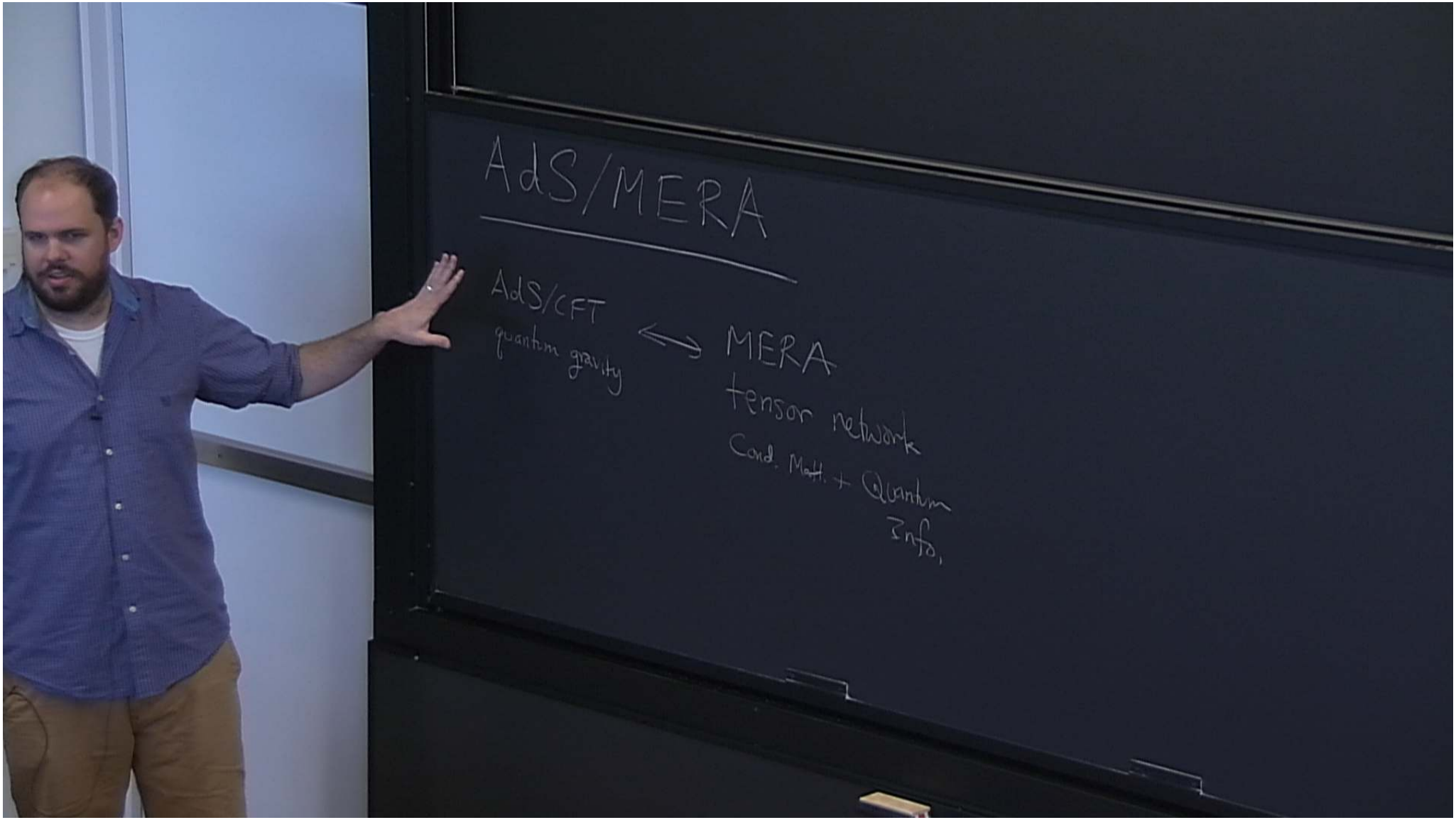
Abstract:

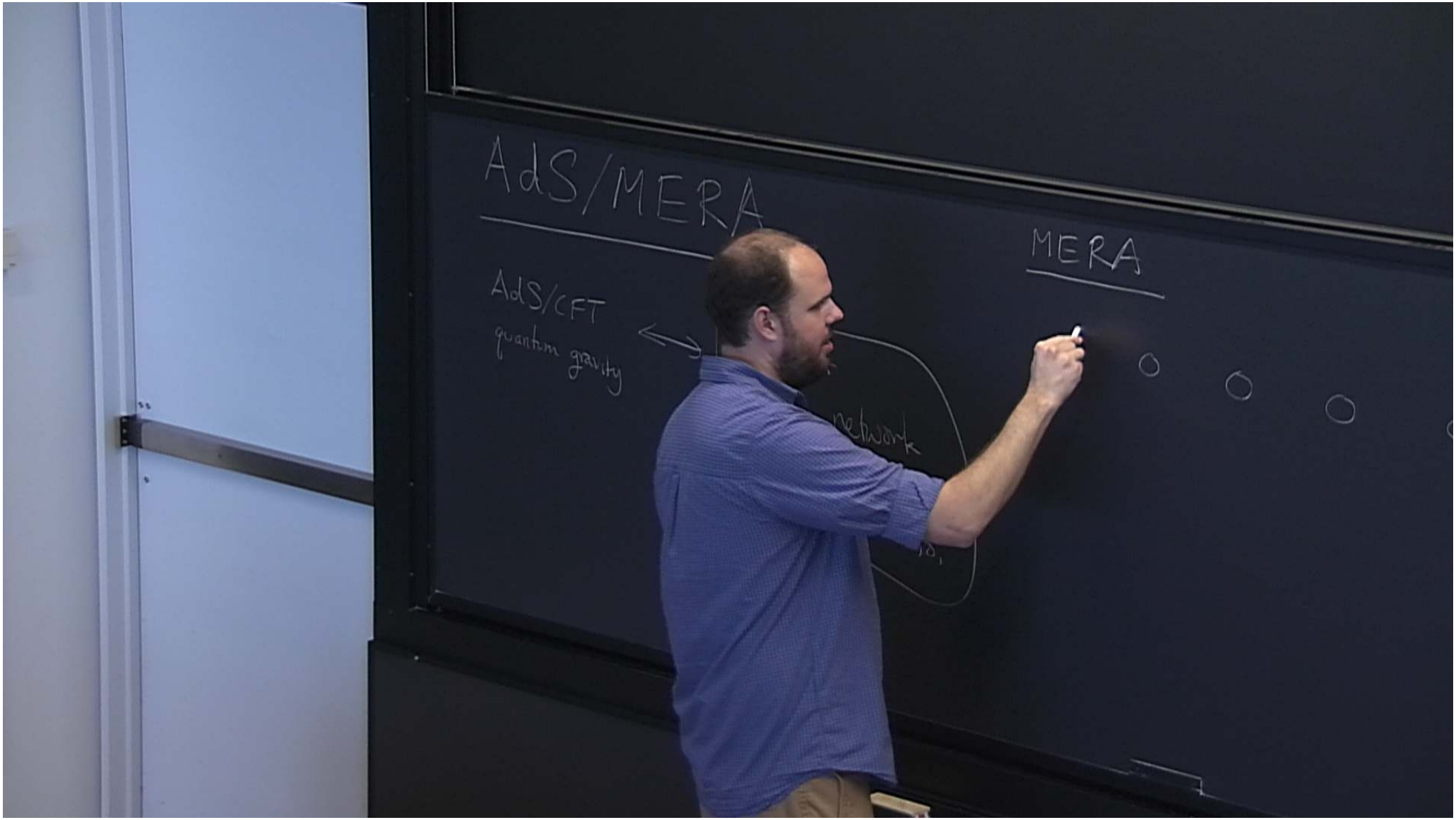

EXIT

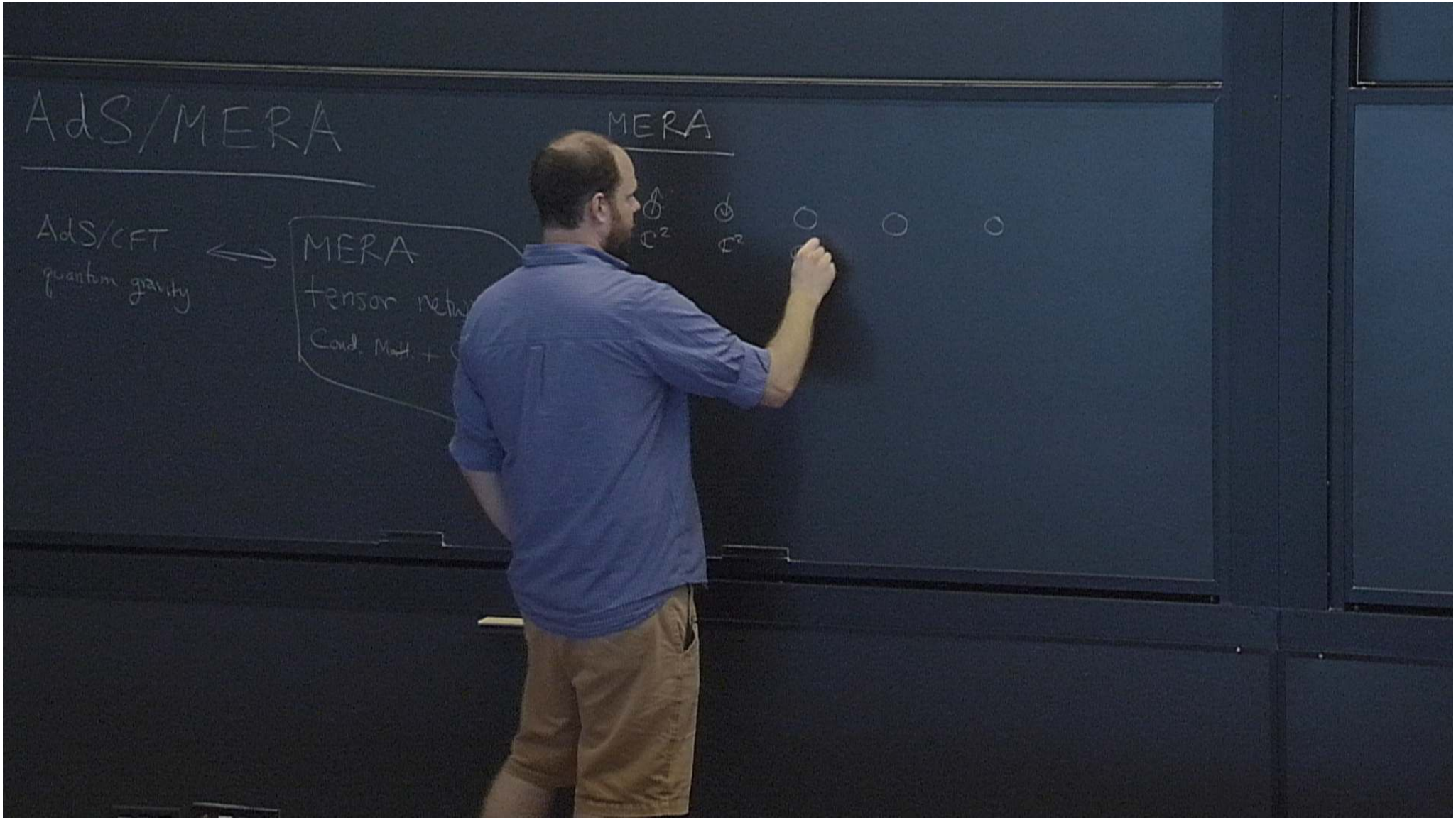

AdS/MERA
AdS/CFT

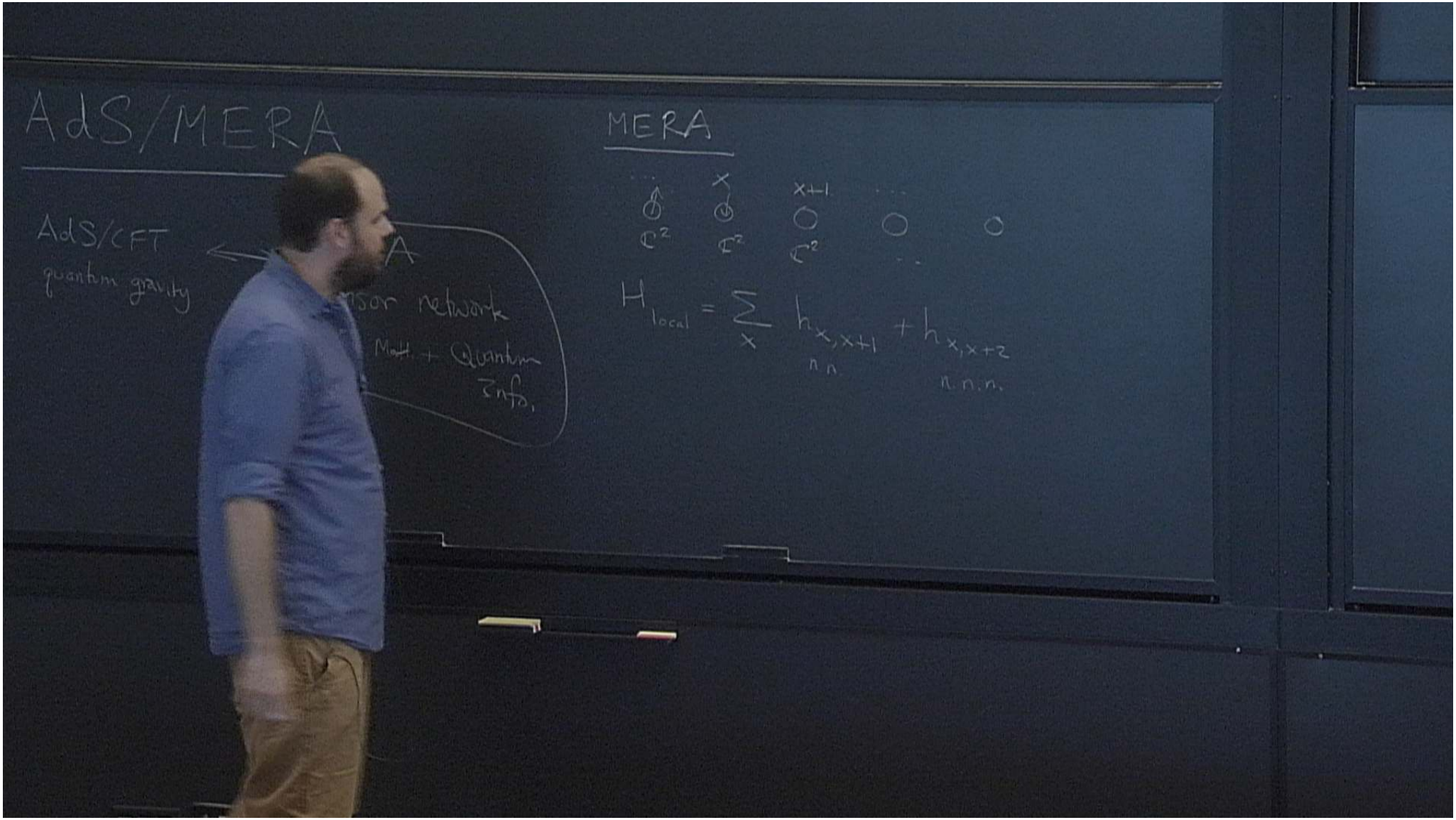

AdS/MERA
/CFT
thm gravity
MERA
tensor network

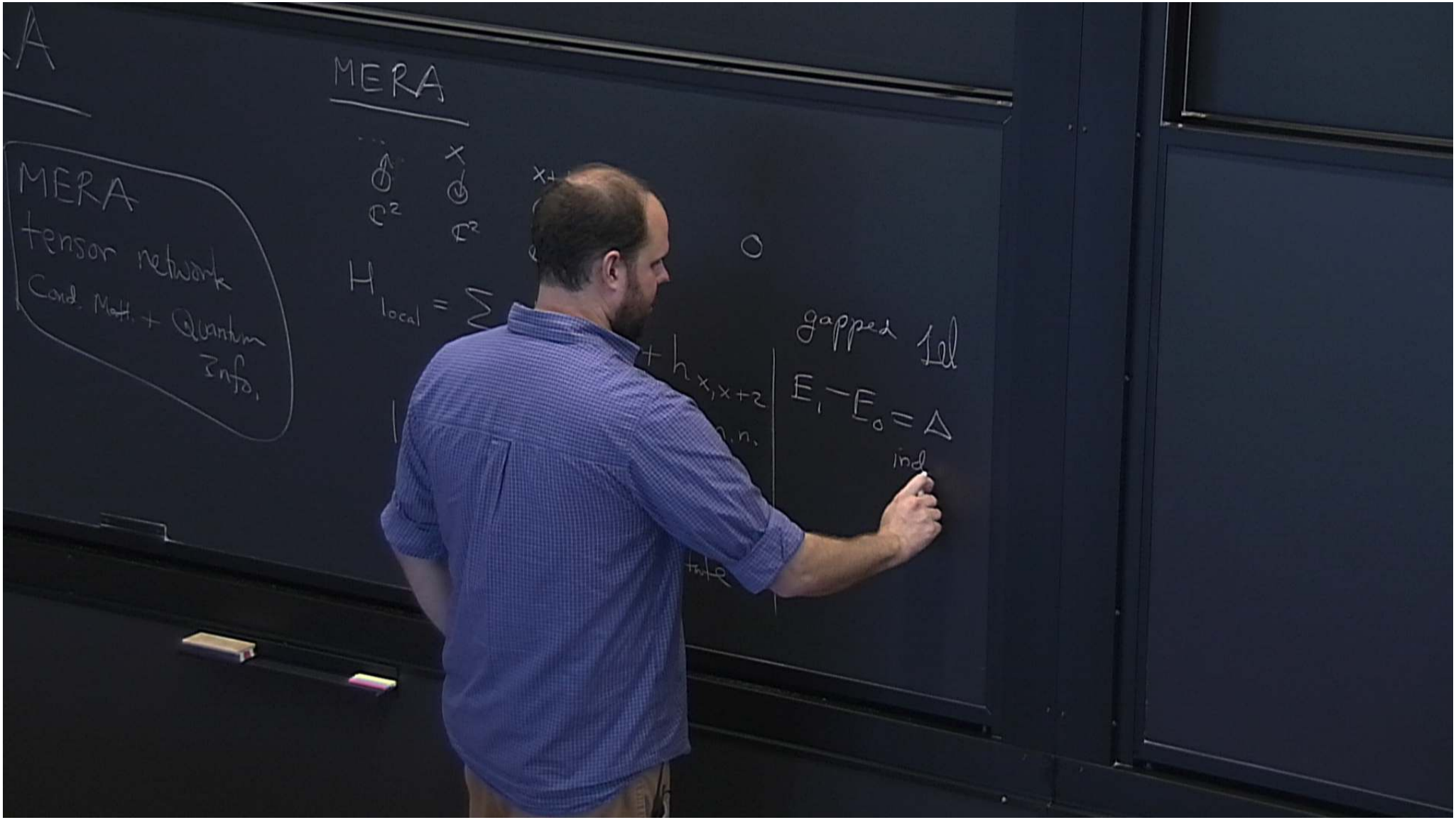

AdS/MERA
AdS/CFT
gravity
MERA
tensor network
Cond. Matt. + Quantum
Info.

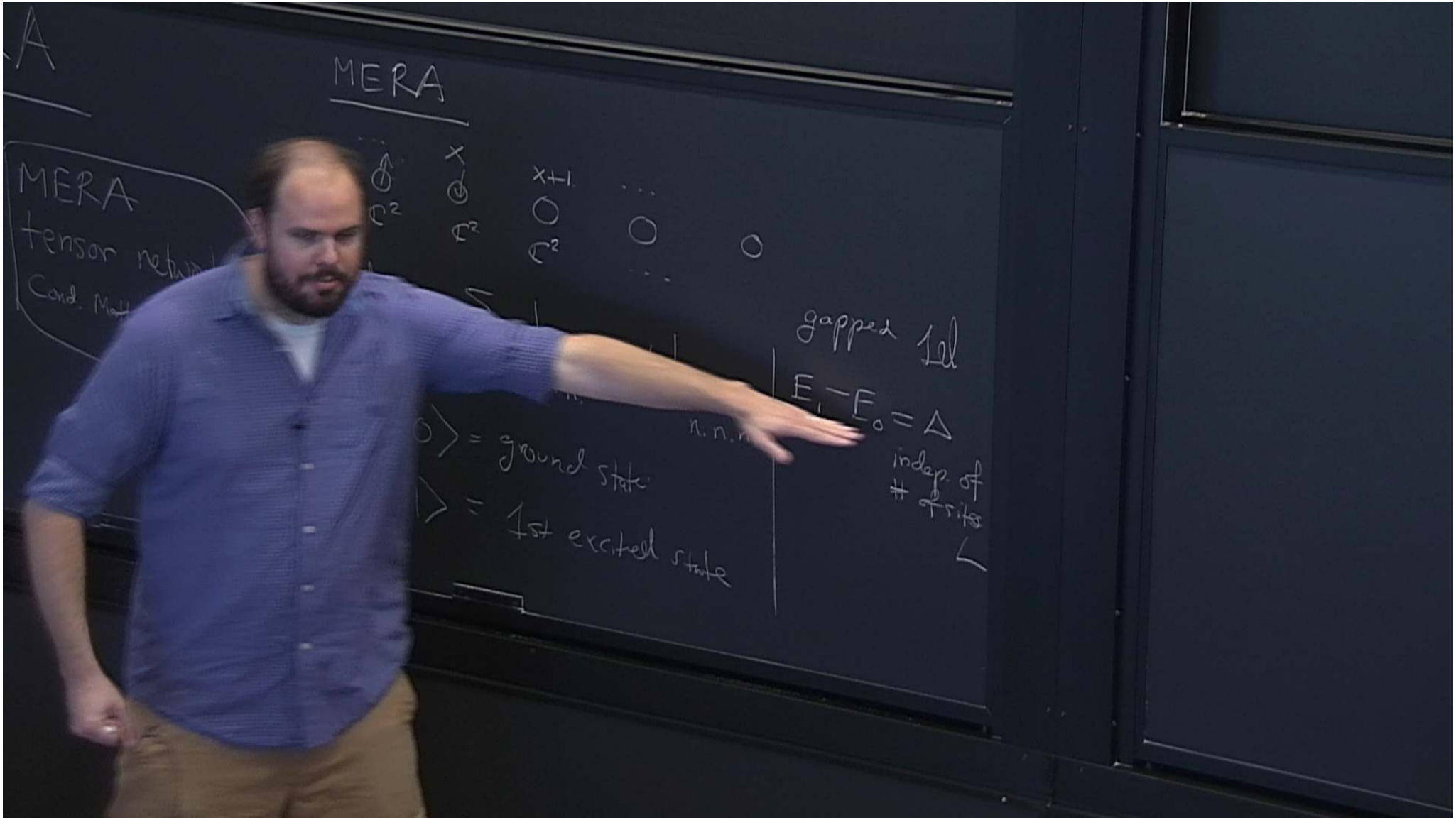

AdS/MERA
AdS/CFT
quantum gravity
⟺
MERA
tensor network
Cond. Matt. + Quantum
Info.

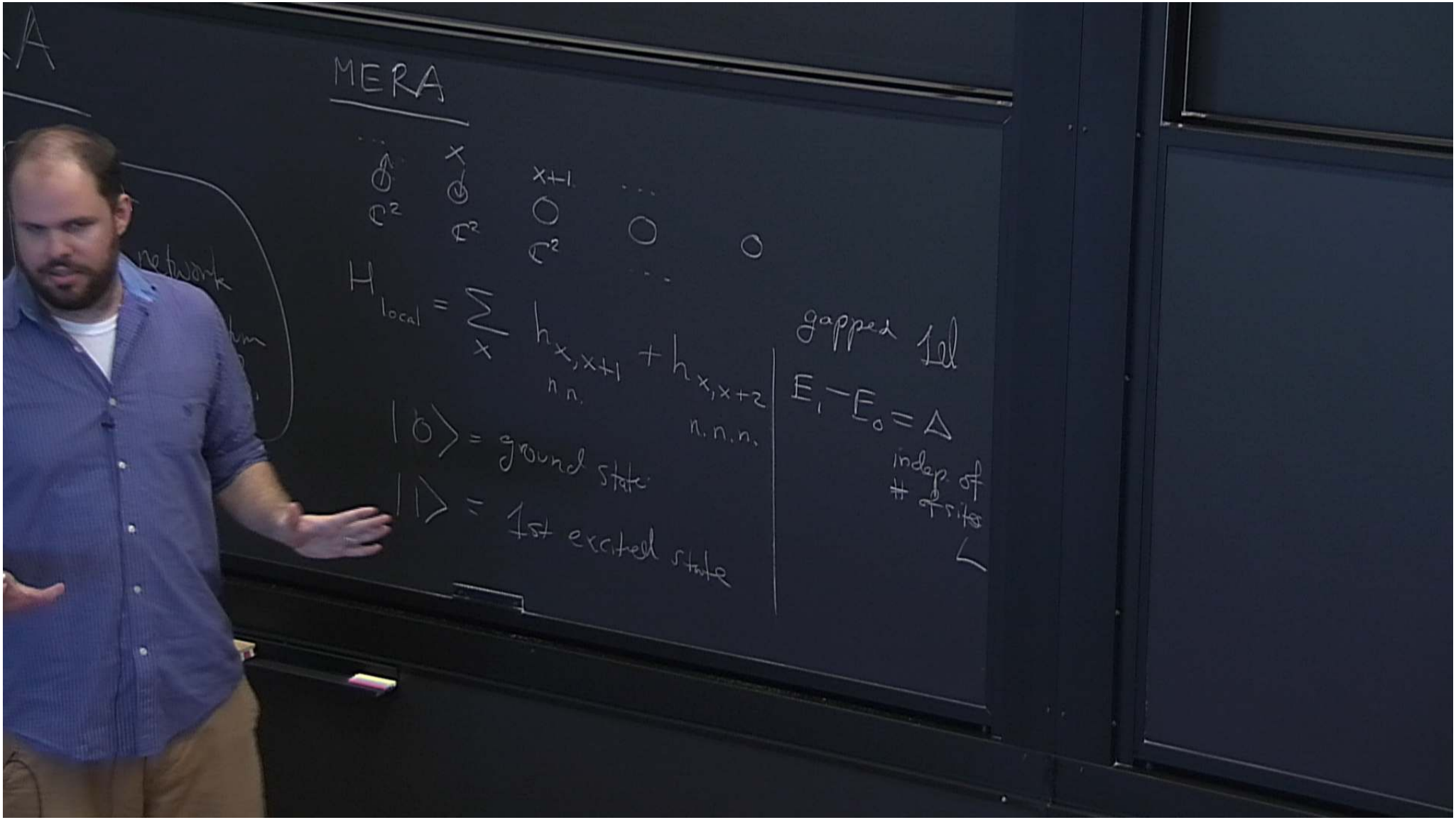

AdS/MERA
AdS/CFT
quantum gravity
MERA

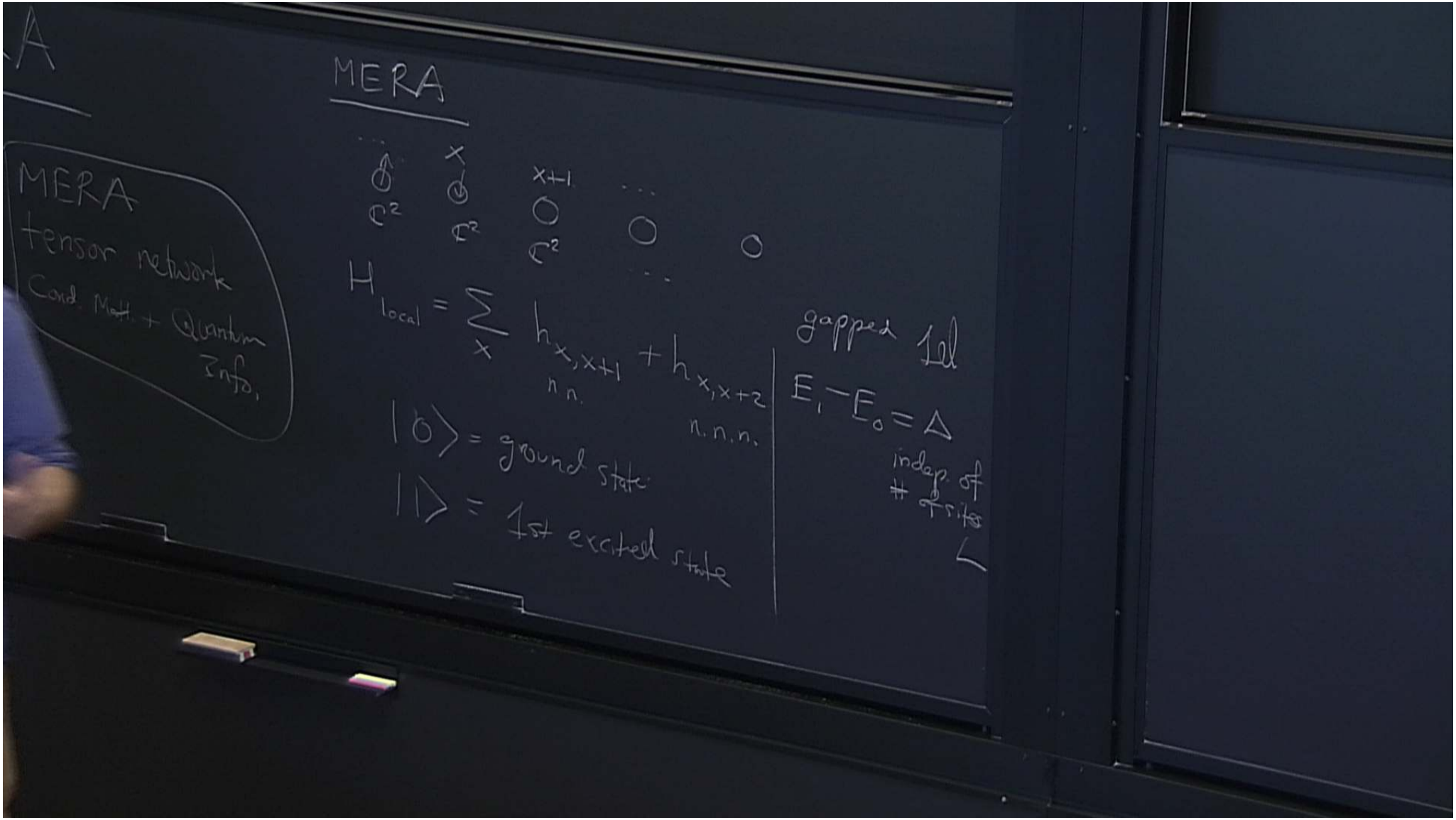

AdS/MERA
AdS/CFT
quantum gravity
MERA
tensor
Cond. Matt.
MERA

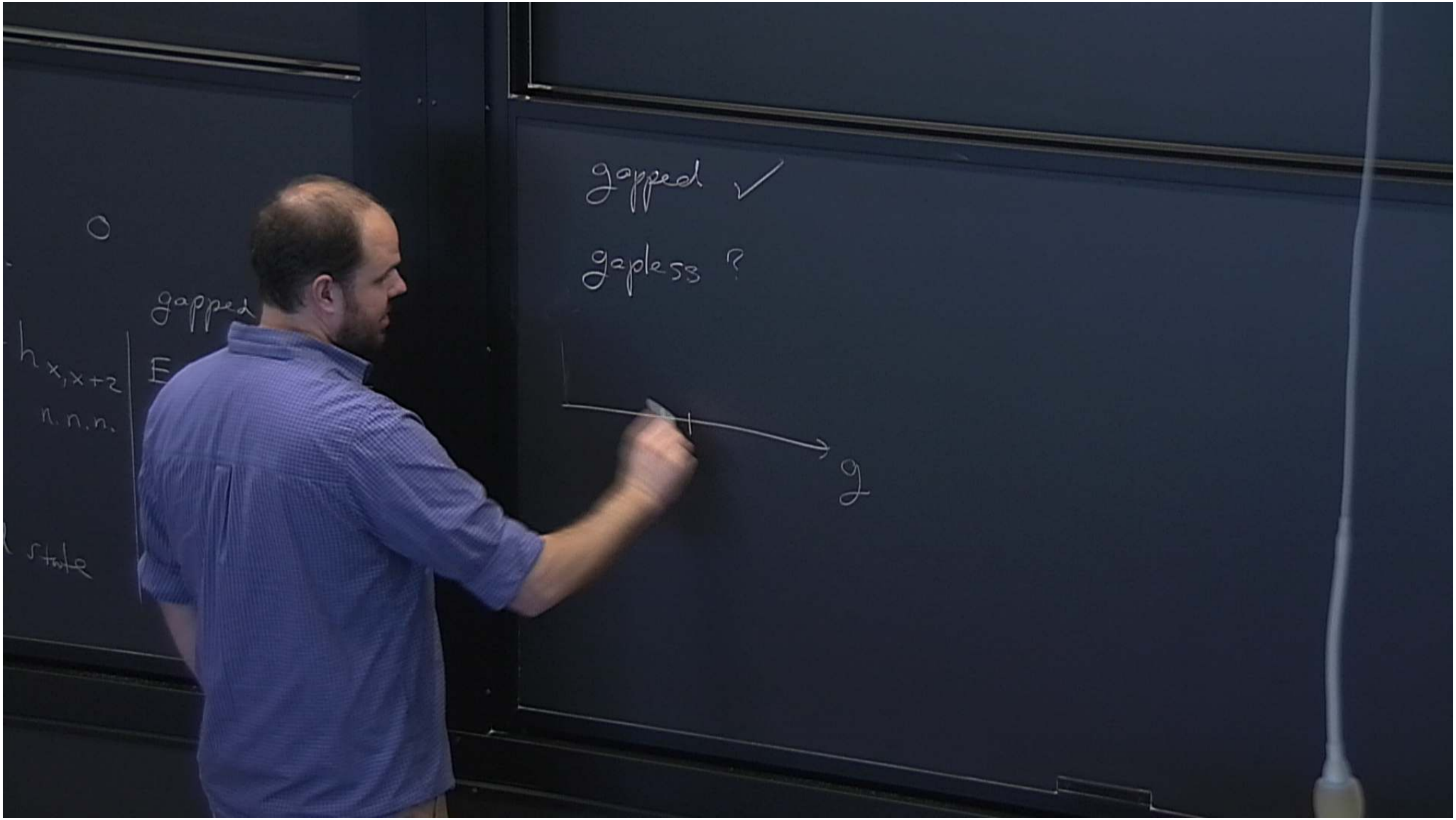

AdS/MERA
AdS/CFT
quantum gravity
tensor network
Math. + Quantum Info.
MERA
x
x+1
$\mathbb{C}^2$
$H_{local} = \sum_x h_{x,x+1} + h_{x,x+2}$
n.n.
n.n.n.

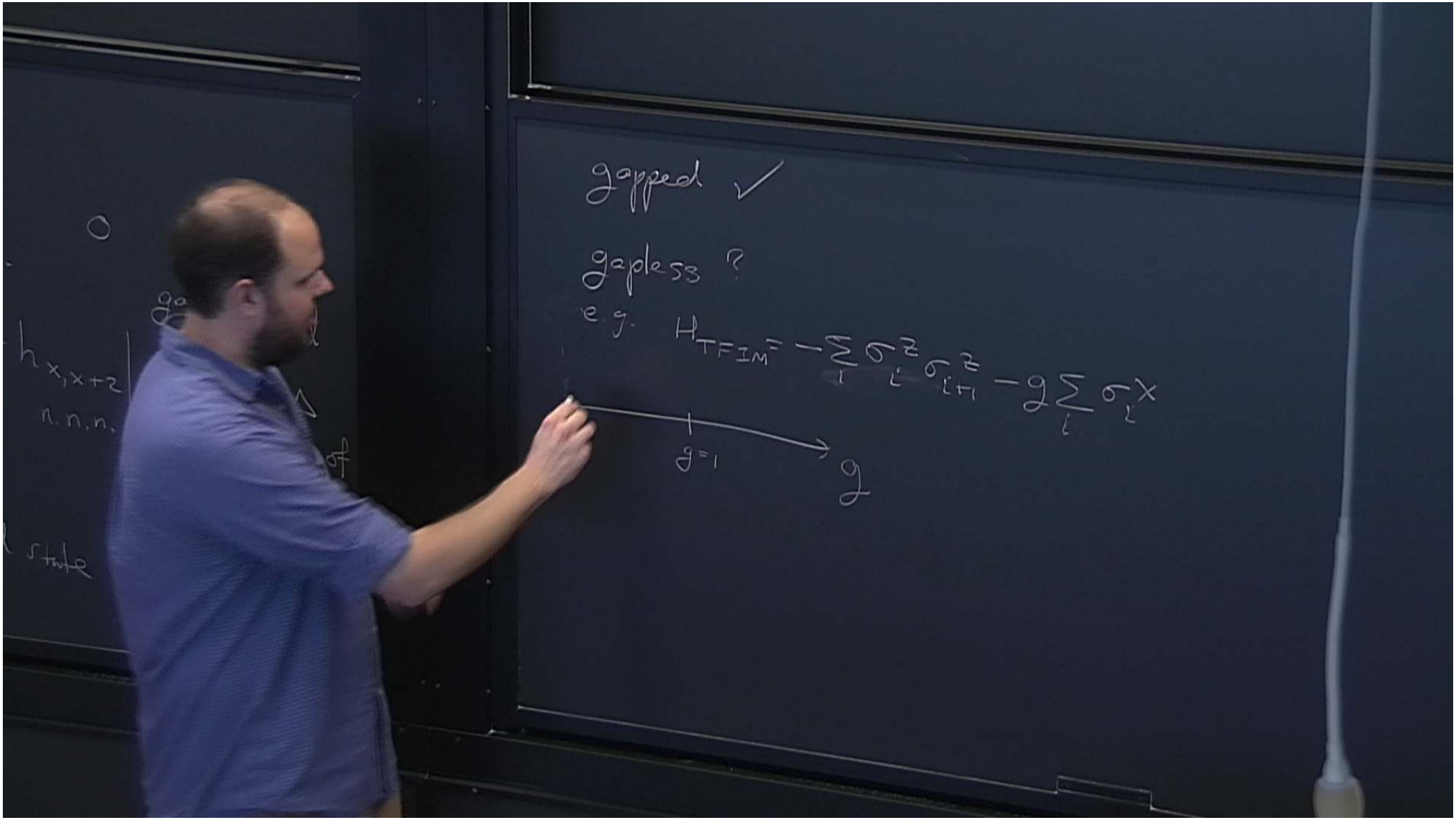

MERA
MERA
tensor network
Cond. Matt. + Quantum
Info.
gapped 1d
ind

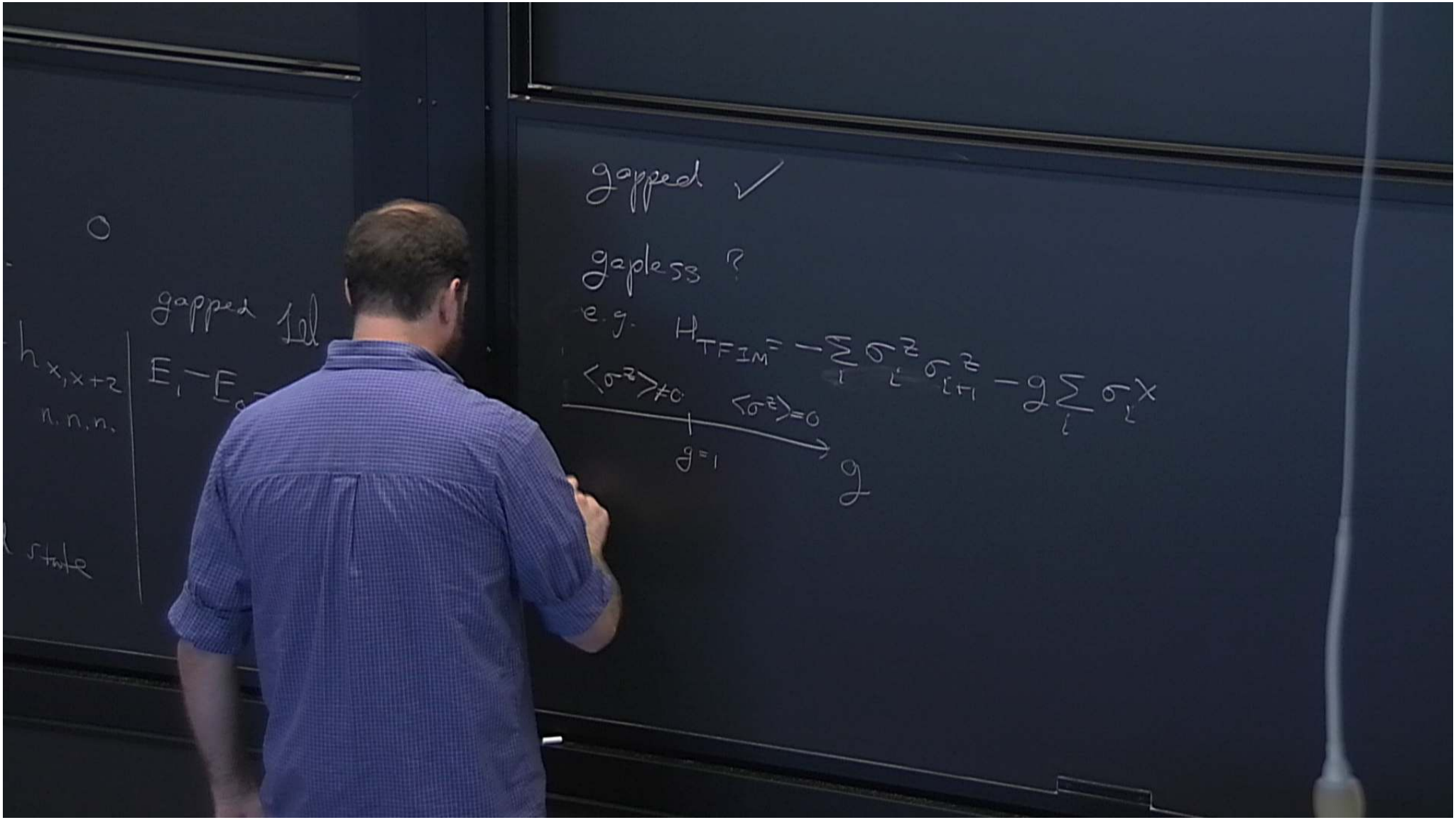

MERA
MERA
tensor
Cond. Mat
x
x+1
gapped 1d
$E_1 - E_0 = \Delta$
indep of
ground state
1st excited state

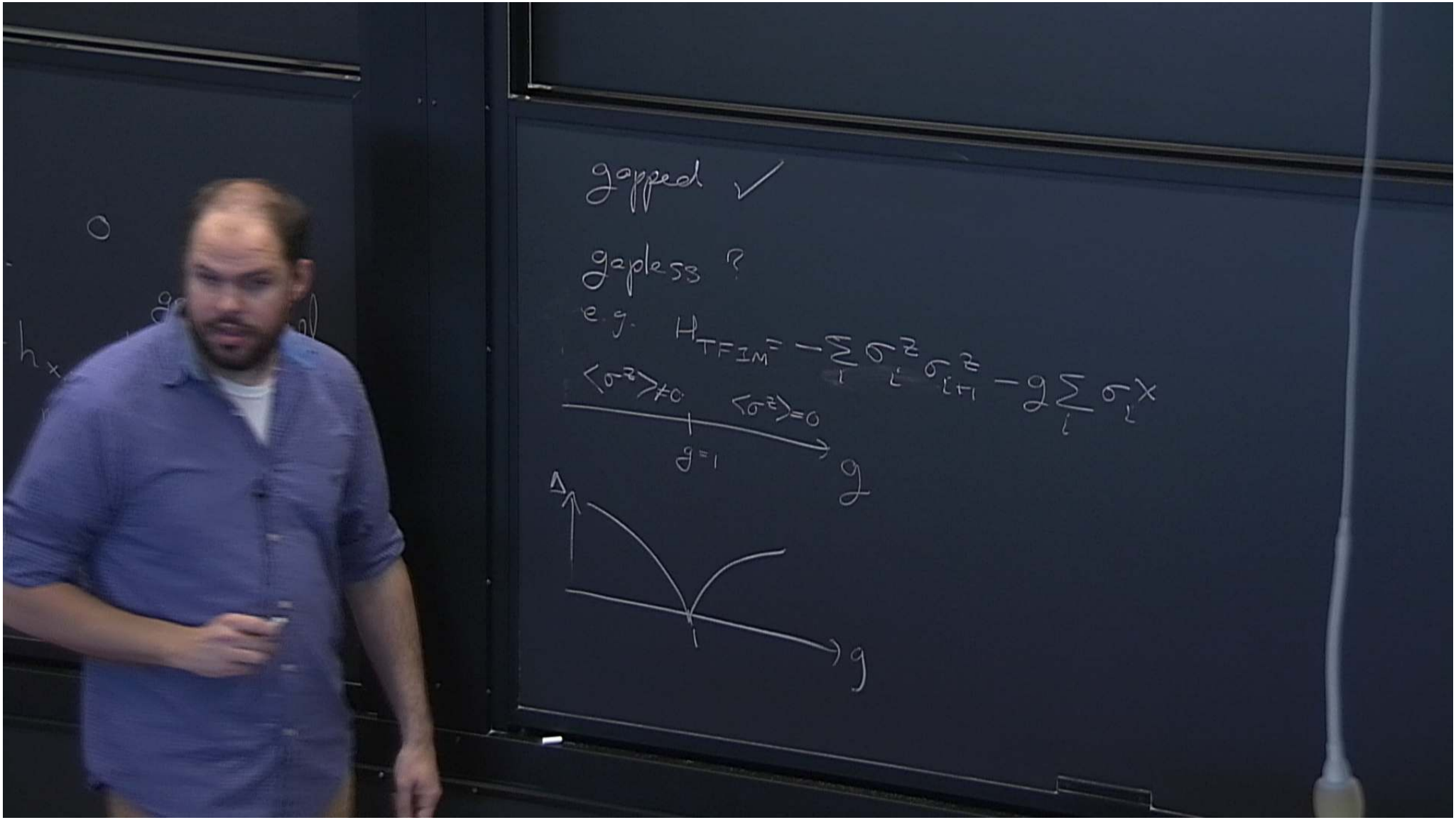

MERA
x
x+1
$\mathbb{C}^2$
$H_{local} = \sum_x h_{x,x+1} + h_{x,x+2}$
n.n.
n.n.n.
$|0\rangle$ = ground state
$|1\rangle$ = 1st excited state
gapped 1d
$E_1 - E_0 = \Delta$
indep of
# of sites

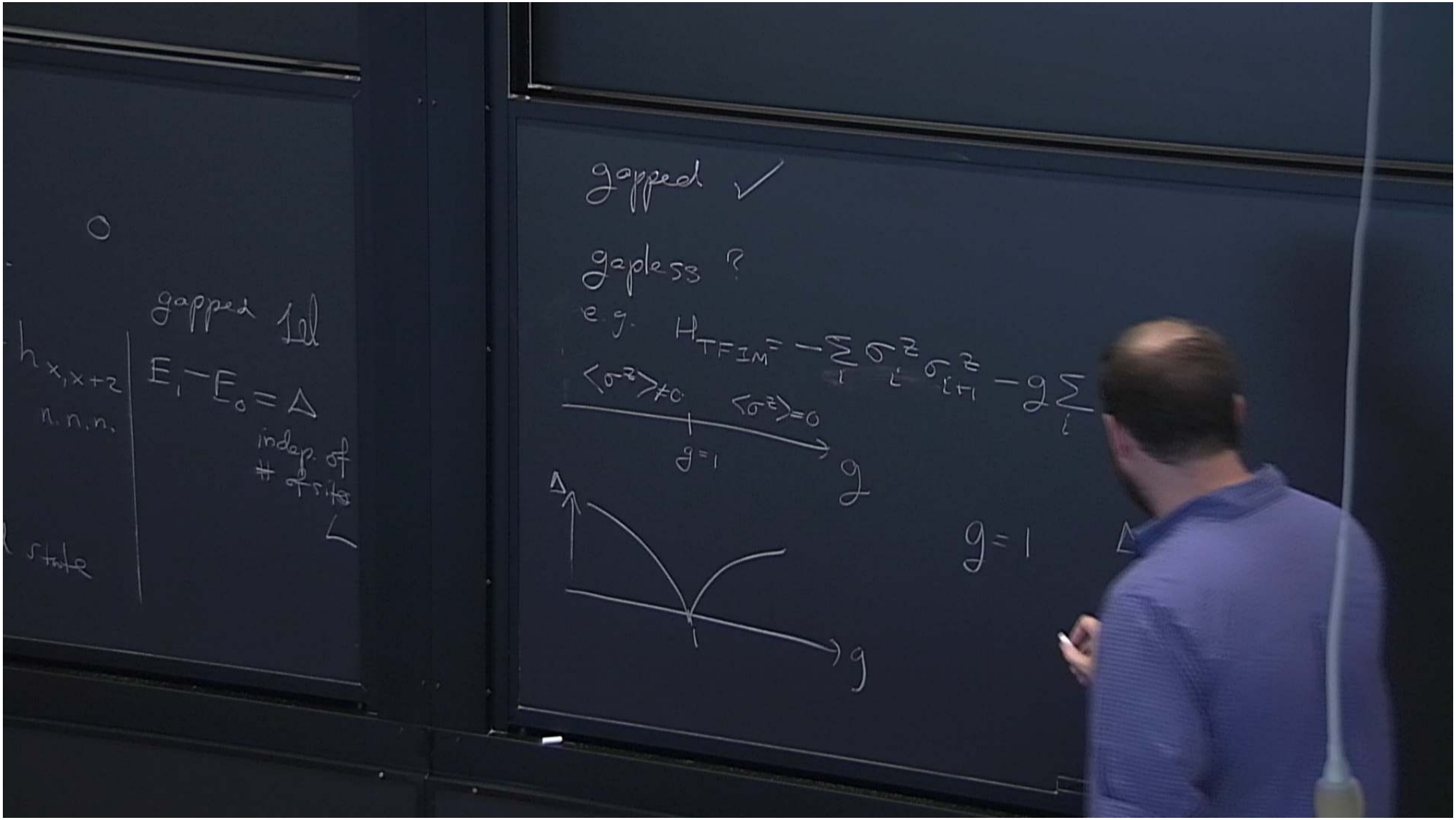

MERA
MERA
tensor network
Cond. Matt. + Quantum Info.
x
x+1
$\mathbb{C}^2$
$H_{local} = \sum_x h_{x,x+1} + h_{x,x+2}$
n.n.
n.n.n.
$|0\rangle$ = ground state
$|1\rangle$ = 1st excited state
gapped 1d
$E_1 - E_0 = \Delta$
indep. of # of sites


gapped ✓
gapless ?
g
gapped
E
n.n.n.


gapped ✓
gapless ?
e.g. $H_{TFIM} = -\sum_i \sigma_i^z \sigma_{i+1}^z - g \sum_i \sigma_i^x$
g=1
g


gapped ✓
gapless ?
e.g. $H_{TFIM} = -\sum_i \sigma_i^z \sigma_{i+1}^z - g\sum_i \sigma_i^x$
$\langle\sigma^z\rangle \neq 0$
$\langle\sigma^z\rangle = 0$
$g=1$
g
gapped 1d
$h_{x,x+2}$
n.n.n.


gapped ✓
gapless ?
e.g. $H_{TFIM} = -\sum_i \sigma_i^z \sigma_{i+1}^z - g\sum_i \sigma_i^x$
$\langle\sigma^z\rangle \neq 0$
$\langle\sigma^z\rangle = 0$
$g=1$
g
Δ
g


gapped ✓
gapless ?
e.g. $H_{TFIM} = -\sum_i \sigma_i^z \sigma_{i+1}^z - g \sum_i$
$\langle \sigma^z \rangle \neq 0$
$\langle \sigma^z \rangle = 0$
$g = 1$
g
Δ
g
$g = 1$
Δ
gapped 1d
$E_1 - E_0 = \Delta$
indep. of # of sites
$h_{x,x+2}$
n.n.n.

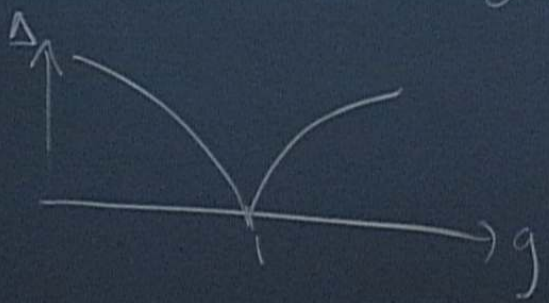
gapped ✓

gapless ?

e.g. $H_{TFIM} = -\sum_i \sigma_i^z \sigma_{i+1}^z - g \sum_i \sigma_i^x$

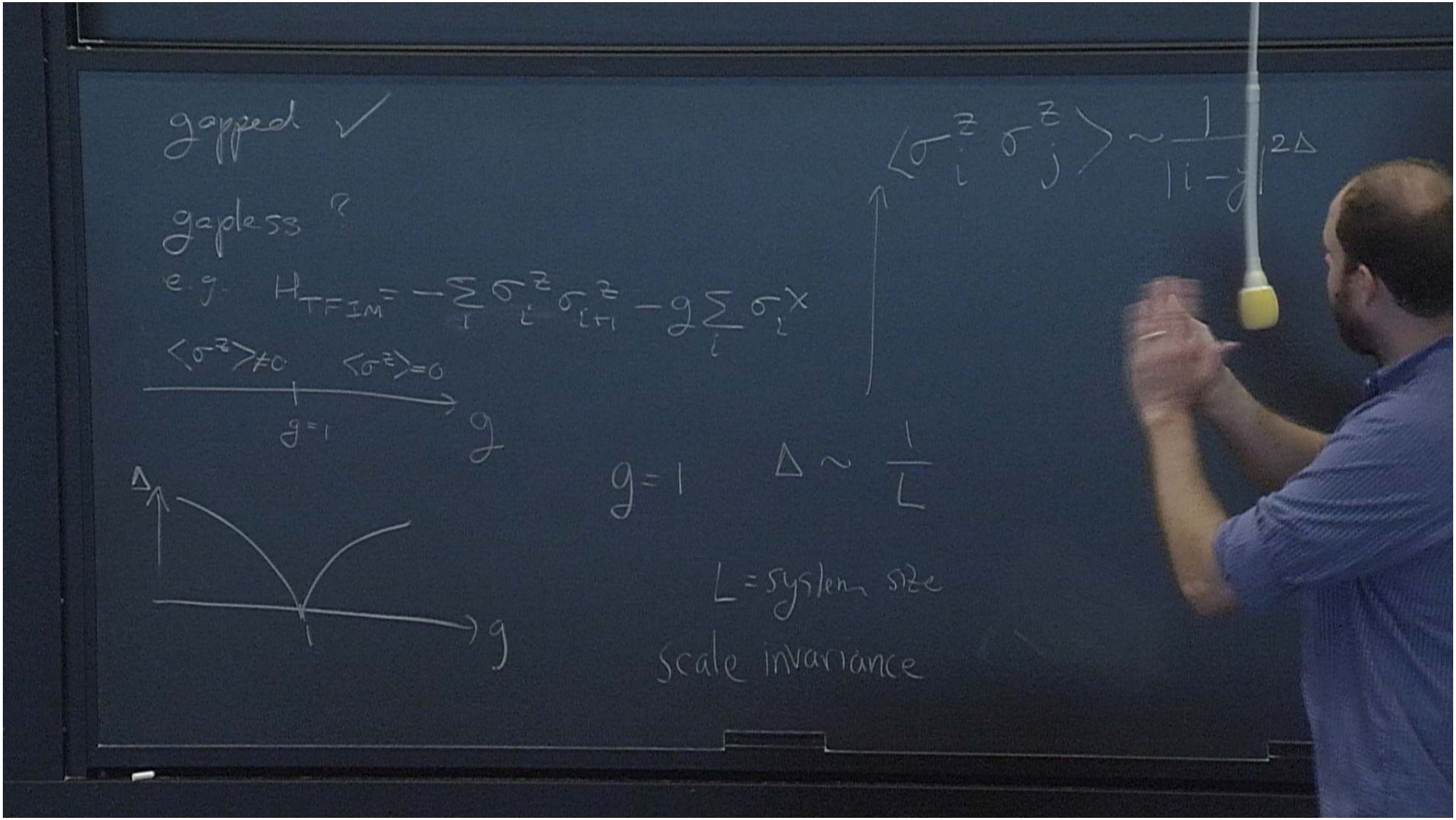
$\langle \sigma^z \rangle \neq 0$ $\langle \sigma^z \rangle = 0$

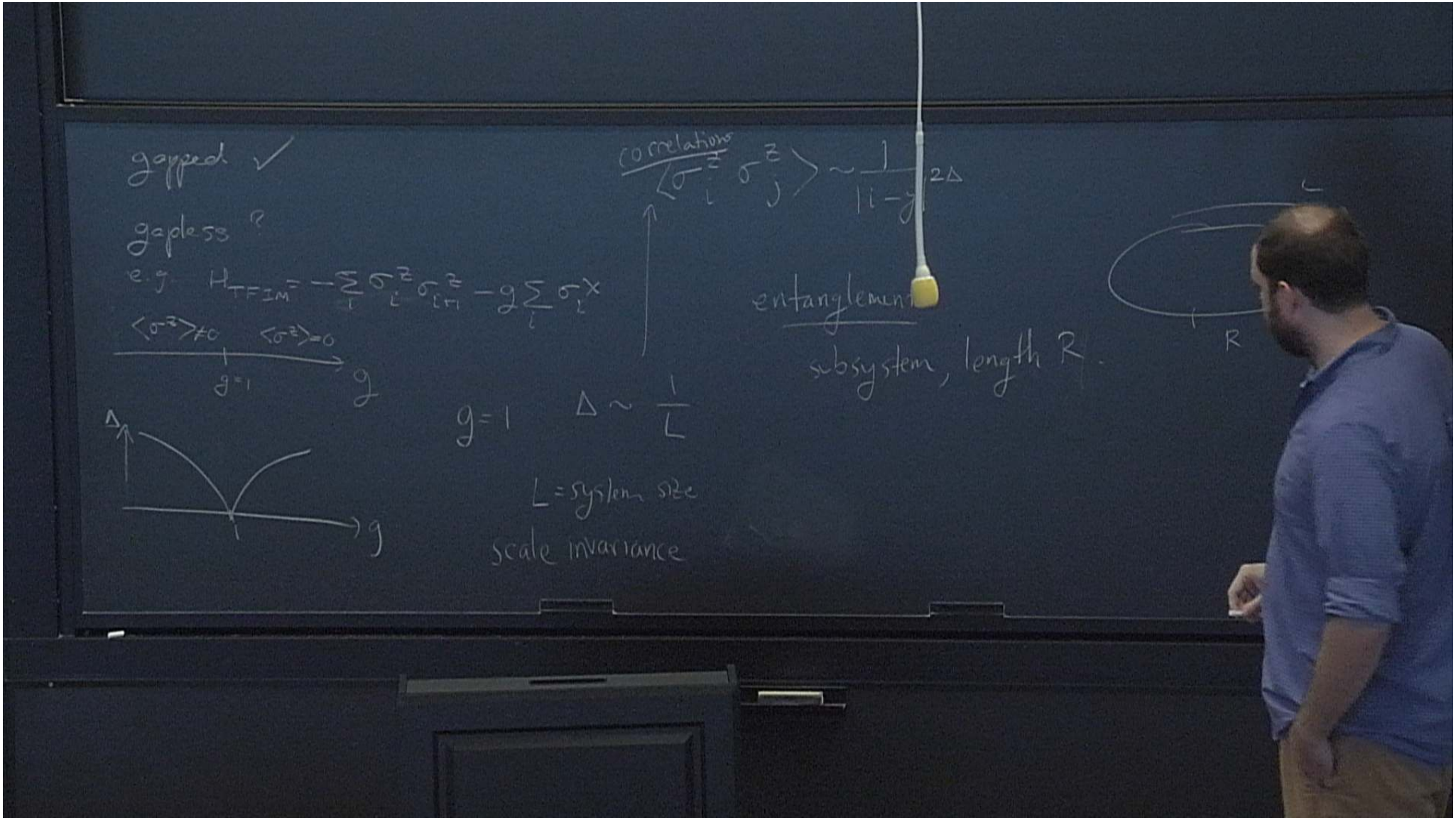
$g = 1$ g



$g = 1$ $\Delta \sim \frac{1}{L}$

L = system size


gapped ✓
gapless ?
e.g. $H_{TFIM} = -\sum_i \sigma_i^z \sigma_{i+1}^z - g \sum_i \sigma_i^x$
$\langle \sigma^z \rangle \neq 0$ $\langle \sigma^z \rangle = 0$
$g=1$
g
Δ
g
$g=1$ $\Delta \sim \frac{1}{L}$
L = system size
scale invariance
$\langle \sigma_i^z \sigma_j^z \rangle \sim \frac{1}{|i-j|^{2\Delta}}$


gapped ✓
gapless ?
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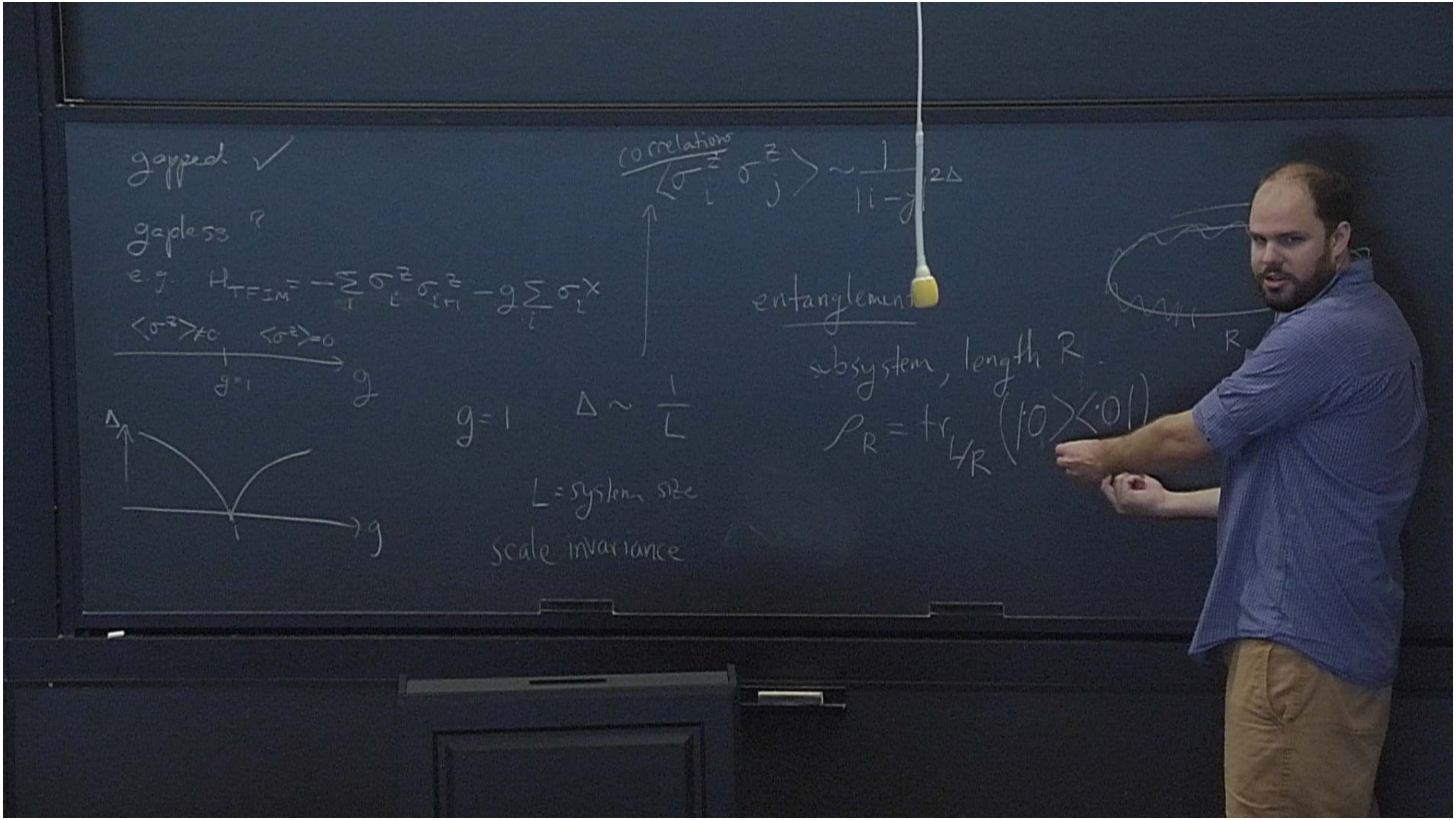
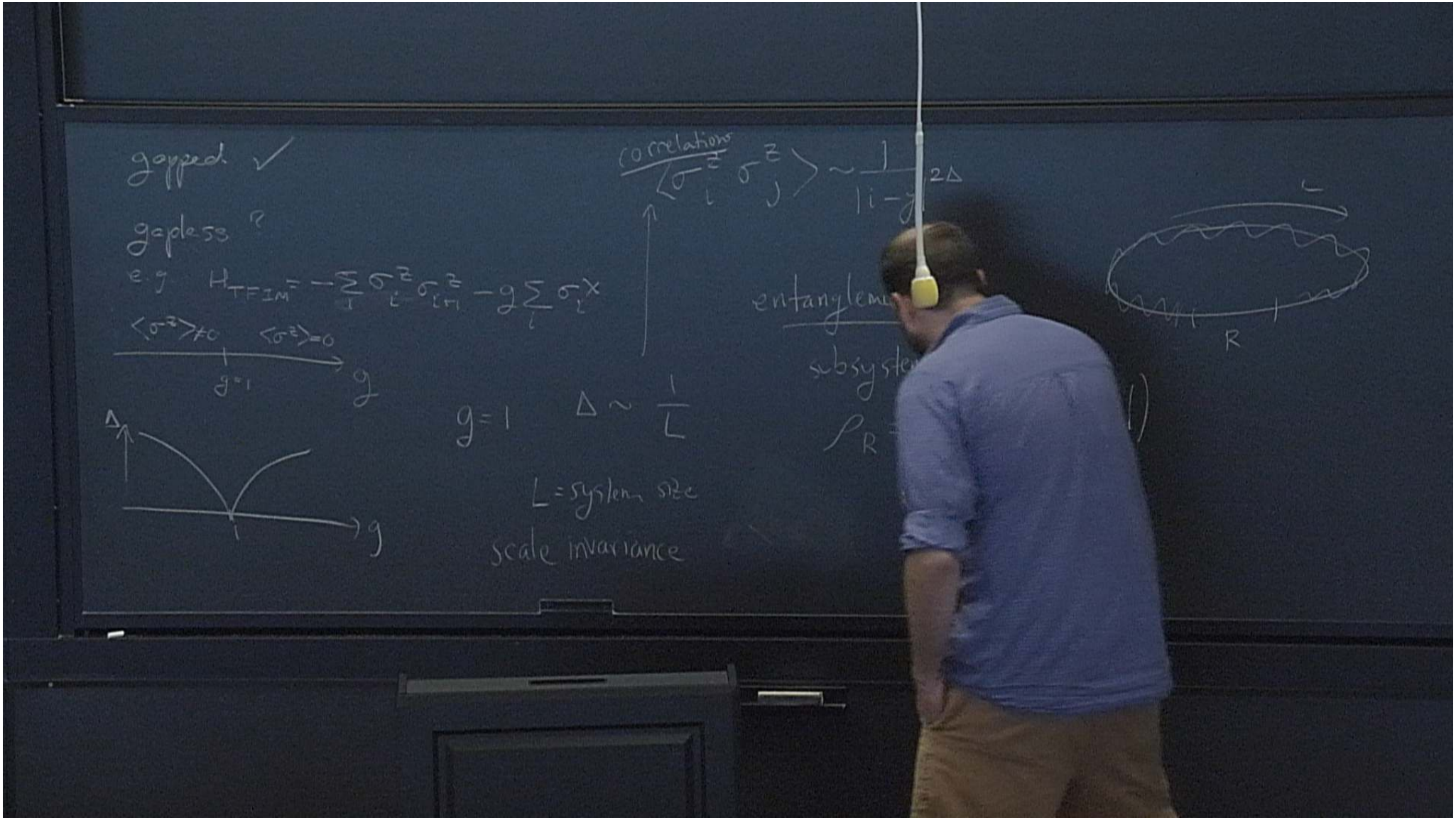
$\langle \sigma^z \rangle \neq 0$ $\langle \sigma^z \rangle = 0$
$g=1$
g
Δ
g
correlations
$\langle \sigma_i^z \sigma_j^z \rangle \sim \frac{1}{|i-j|^{2\Delta}}$
entanglement
subsystem, length R
R
$g=1$ $\Delta \sim \frac{1}{L}$
L = system size
scale invariance


gapped ✓
gapless ?
e.g. $H_{TFIM} = -\sum_i \sigma_i^z \sigma_{i+1}^z - g\sum_i \sigma_i^x$
$\langle\sigma^z\rangle \neq 0$ $\langle\sigma^z\rangle = 0$
$g=1$
g
Δ
g
correlations $\langle \sigma_i^z \sigma_j^z \rangle \sim \frac{1}{|i-j|^{2\Delta}}$
entanglement
subsystem, length R.
$\rho_R = tr_{L/R}(|0\rangle\langle 0|)$
R
$g=1$ $\Delta \sim \frac{1}{L}$
L = system size
scale invariance


gapped ✓
gapless ?
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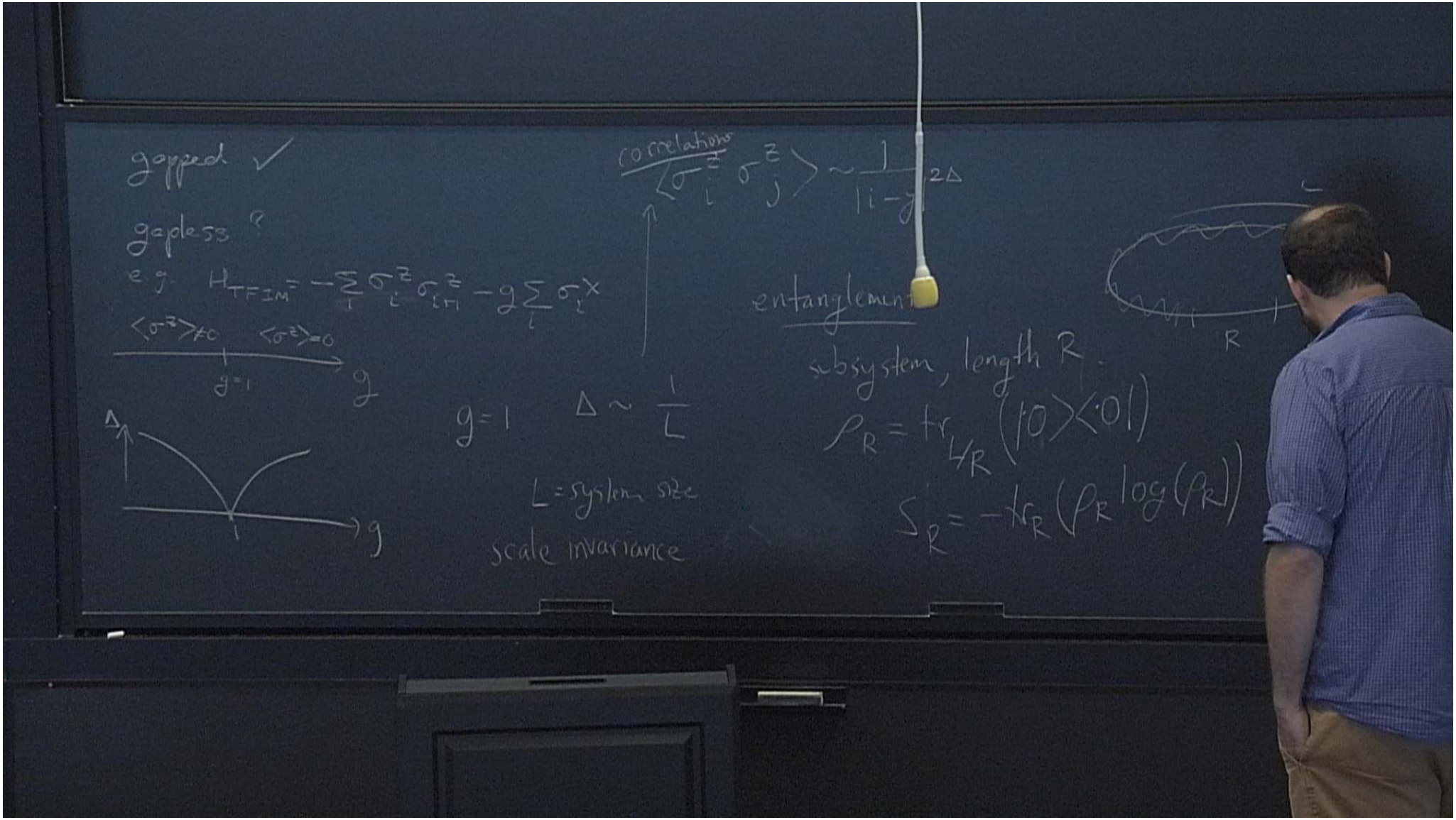
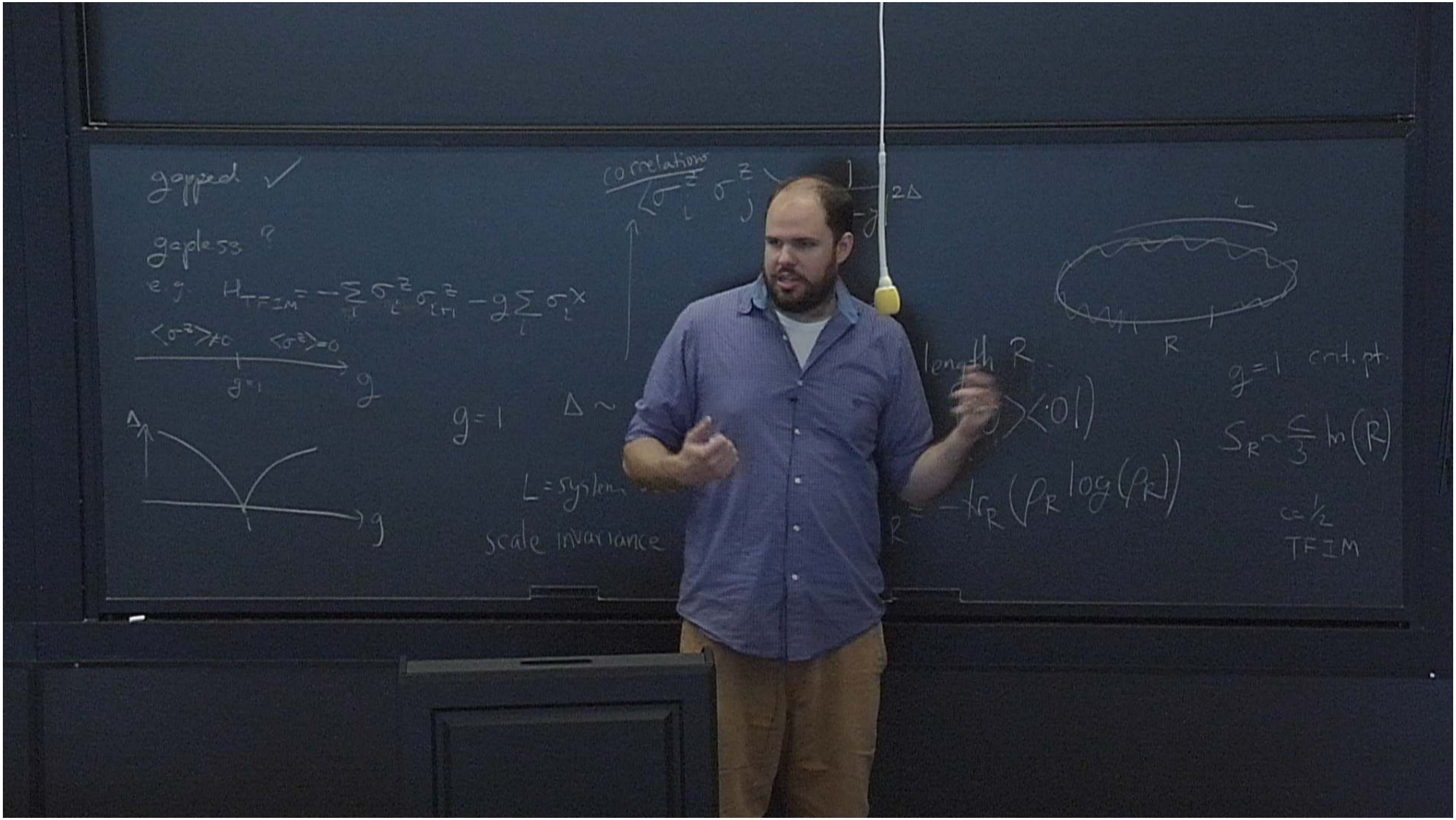
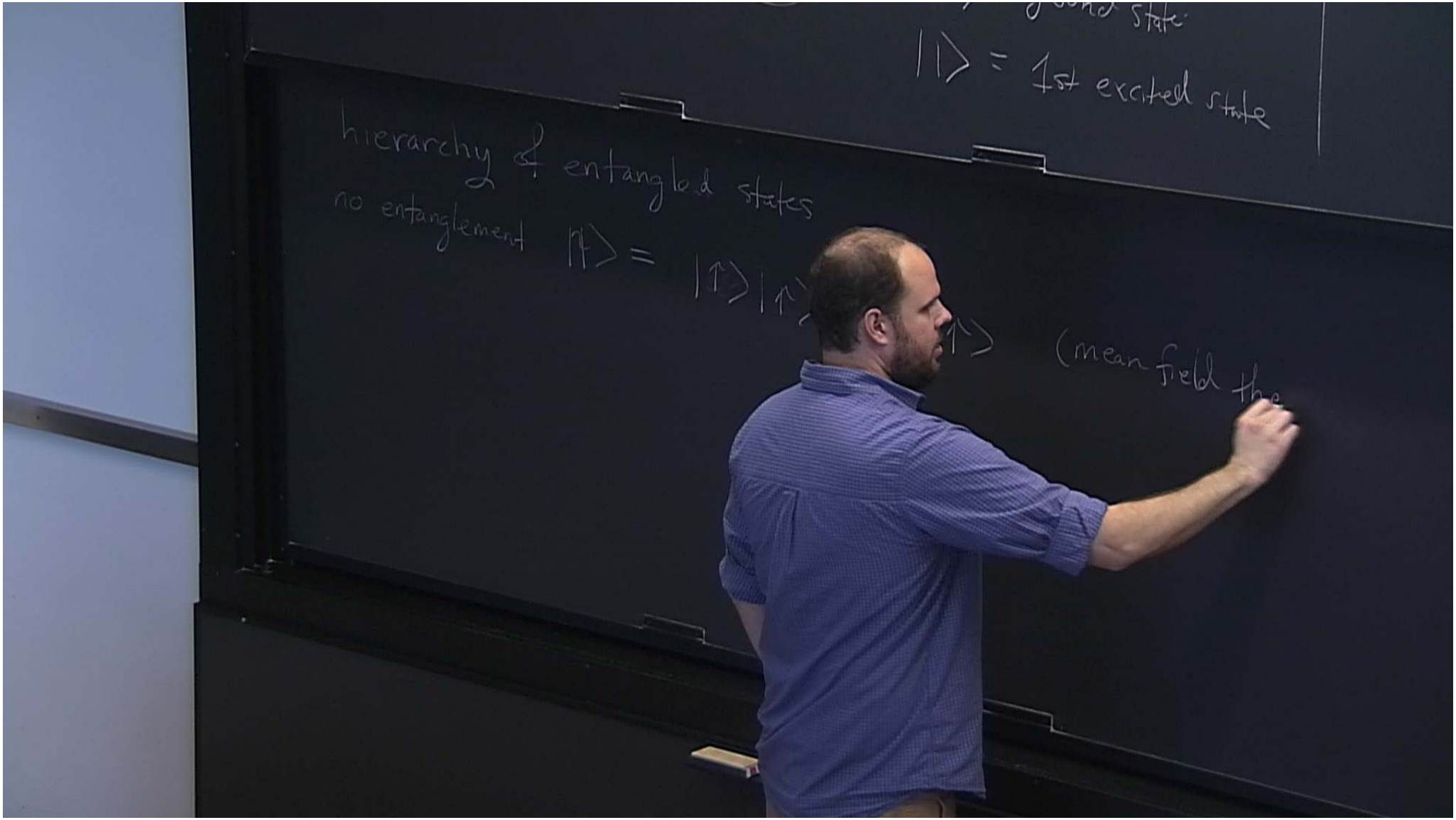
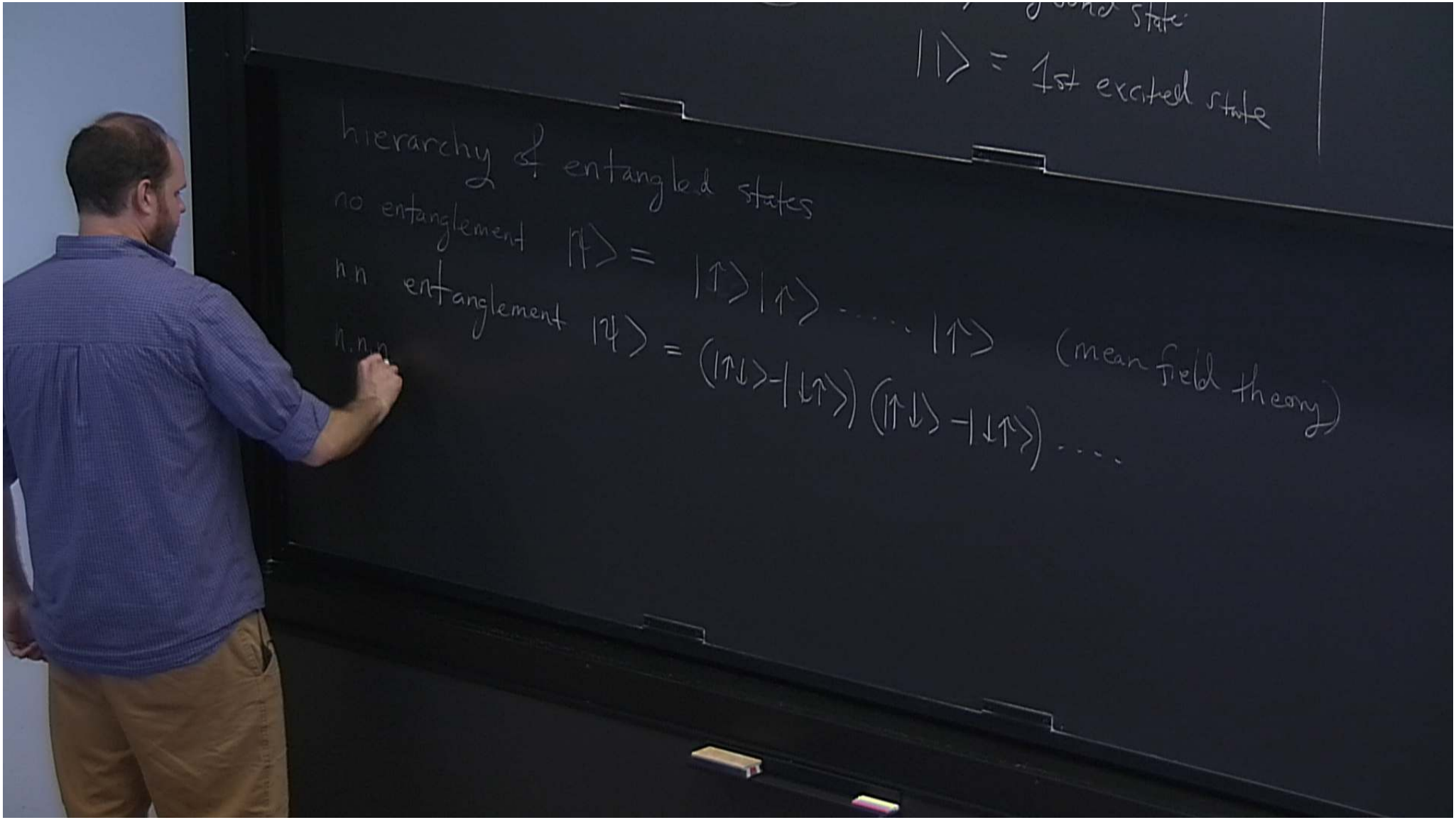
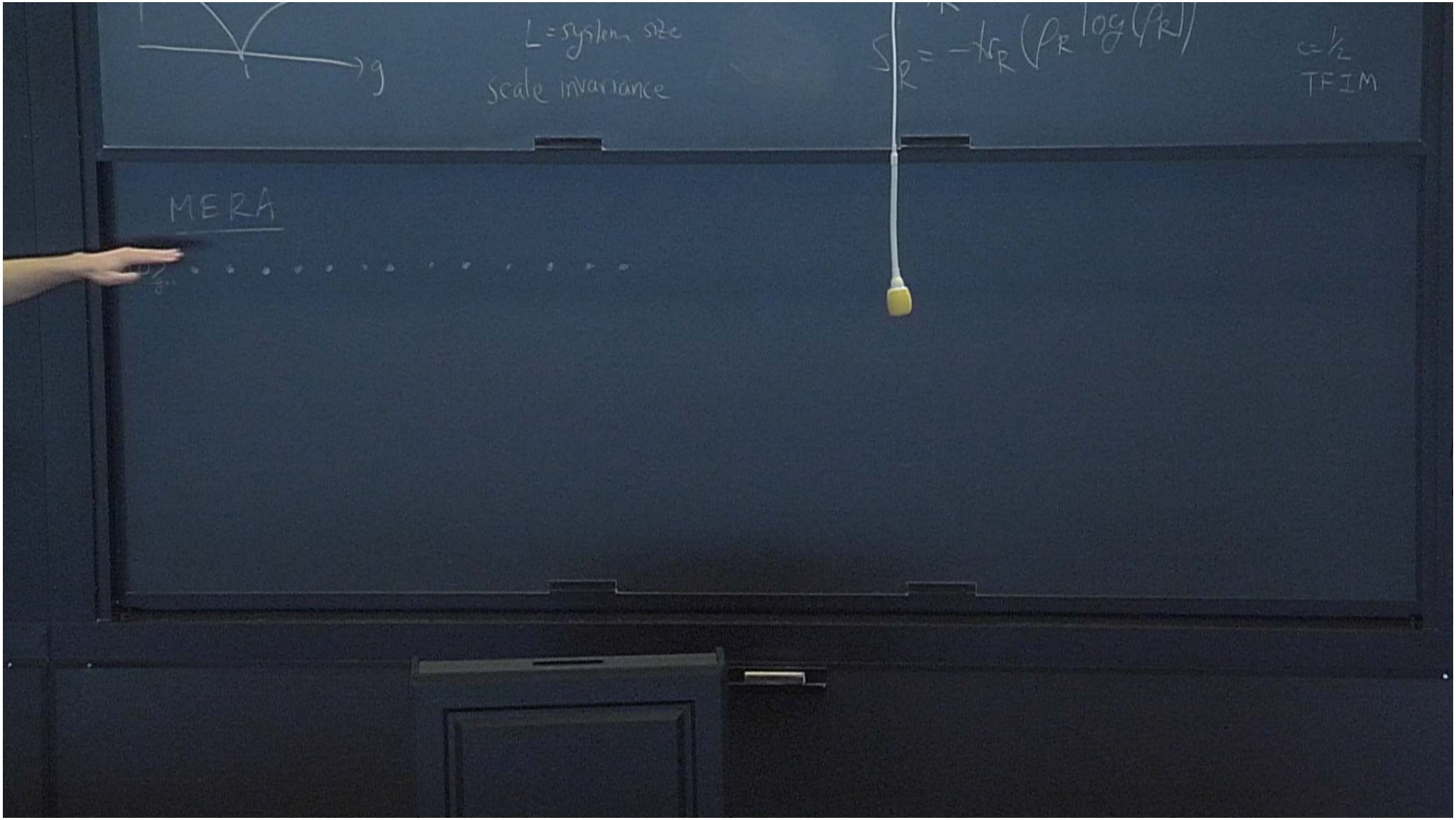
correlation
$\langle \sigma_i^z \sigma_j^z \rangle \sim \frac{1}{|i-j|^{2\Delta}}$
entanglem
subsyste
ρ_R
$\langle \sigma^z \rangle \neq 0$ $\langle \sigma^z \rangle = 0$
$g=1$
g
Δ
$g=1$ $\Delta \sim \frac{1}{L}$
L = system size
scale invariance
L
R

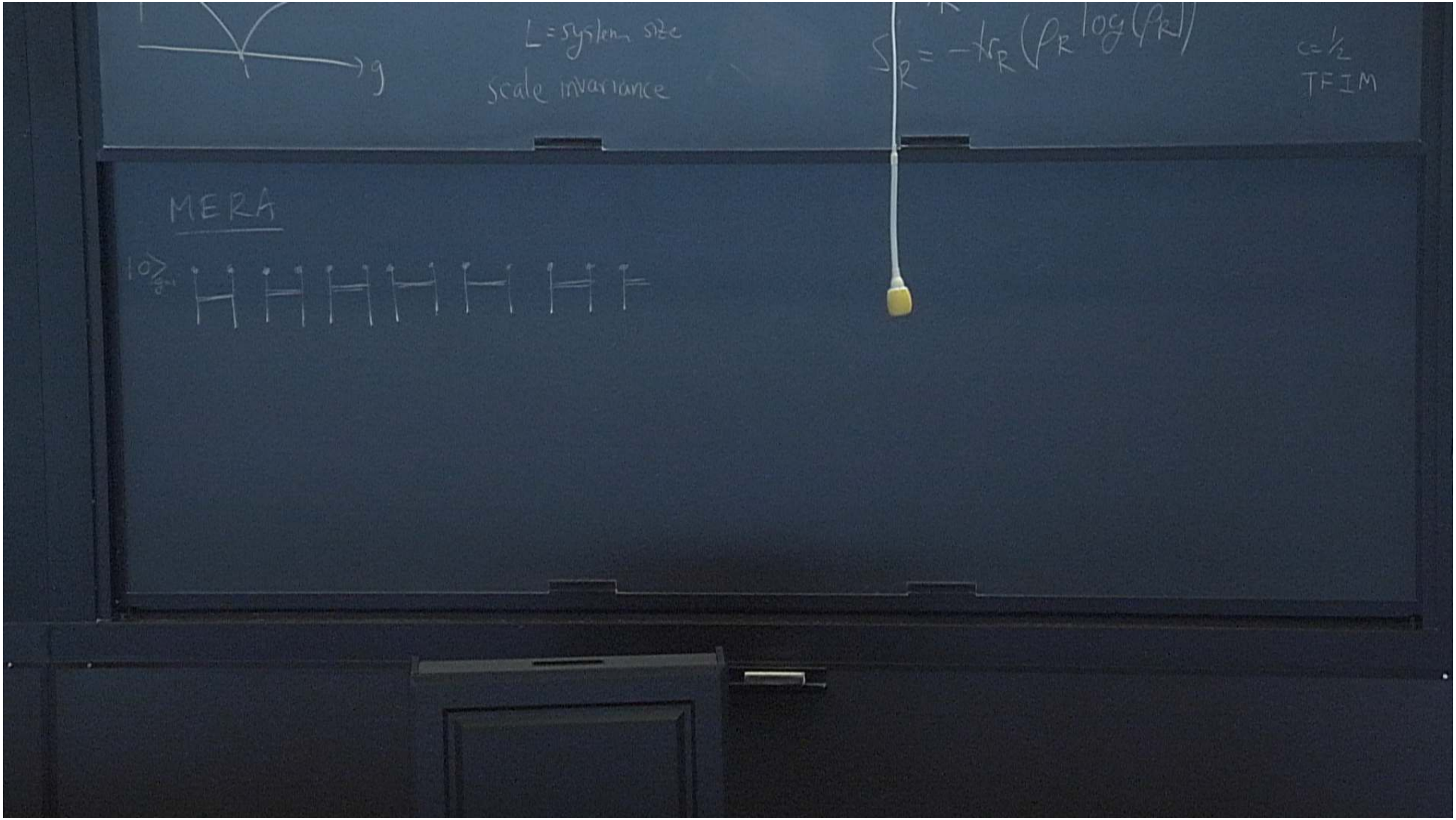

gapped ✓
gapless ?
e.g. $H_{TFIM} = -\sum_i \sigma_i^z \sigma_{i+1}^z - g\sum_i \sigma_i^x$
$\langle \sigma^z \rangle \neq 0$ $\langle \sigma^z \rangle = 0$
$g=1$
g
Δ
g
correlations
$\langle \sigma_i^z \sigma_j^z \rangle \sim \frac{1}{|i-j|^{2\Delta}}$
entanglement
$g=1$ $\Delta \sim \frac{1}{L}$
L = system size
scale invariance
subsystem, length R.
$\rho_R = tr_{L/R}(|0\rangle\langle 0|)$
$S_R = -tr_R(\rho_R \log(\rho_R))$
R


gapped ✓
gapless ?
e.g. $H_{TFIM} = -\sum_i \sigma_i^z \sigma_{i+1}^z - g \sum_i \sigma_i^x$
$\langle \sigma^z \rangle \neq 0$ $\langle \sigma^z \rangle = 0$
g=1
g
Δ
g=1
$\Delta \sim$
L = system
scale invariance
correlations
$\langle \sigma_i^z \sigma_j^z \rangle$
2Δ
length R
$\rangle\langle 0|)$
$= -\mathrm{tr}_R(\rho_R \log(\rho_R))$
R
g=1 crit. pt.
$S_R \sim \frac{c}{3} \ln(R)$
c=1/2
TFIM


|1> = 1st excited state
hierarchy of entangled states
no entanglement
(mean field


|1> = 1st excited state
hierarchy of entangled states
no entanglement |ψ> = |↑>|↑> ..... |↑>
n.n entanglement |ψ> = (|↑↓> - |↓↑>)(|↑↓> - |↓↑>) ....
(mean field theory)
n.n.n


L = system size
scale invariance
$S_R = -\mathrm{tr}_R(\rho_R \log(\rho_R))$
c = ½
TFIM
MERA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scale invariance
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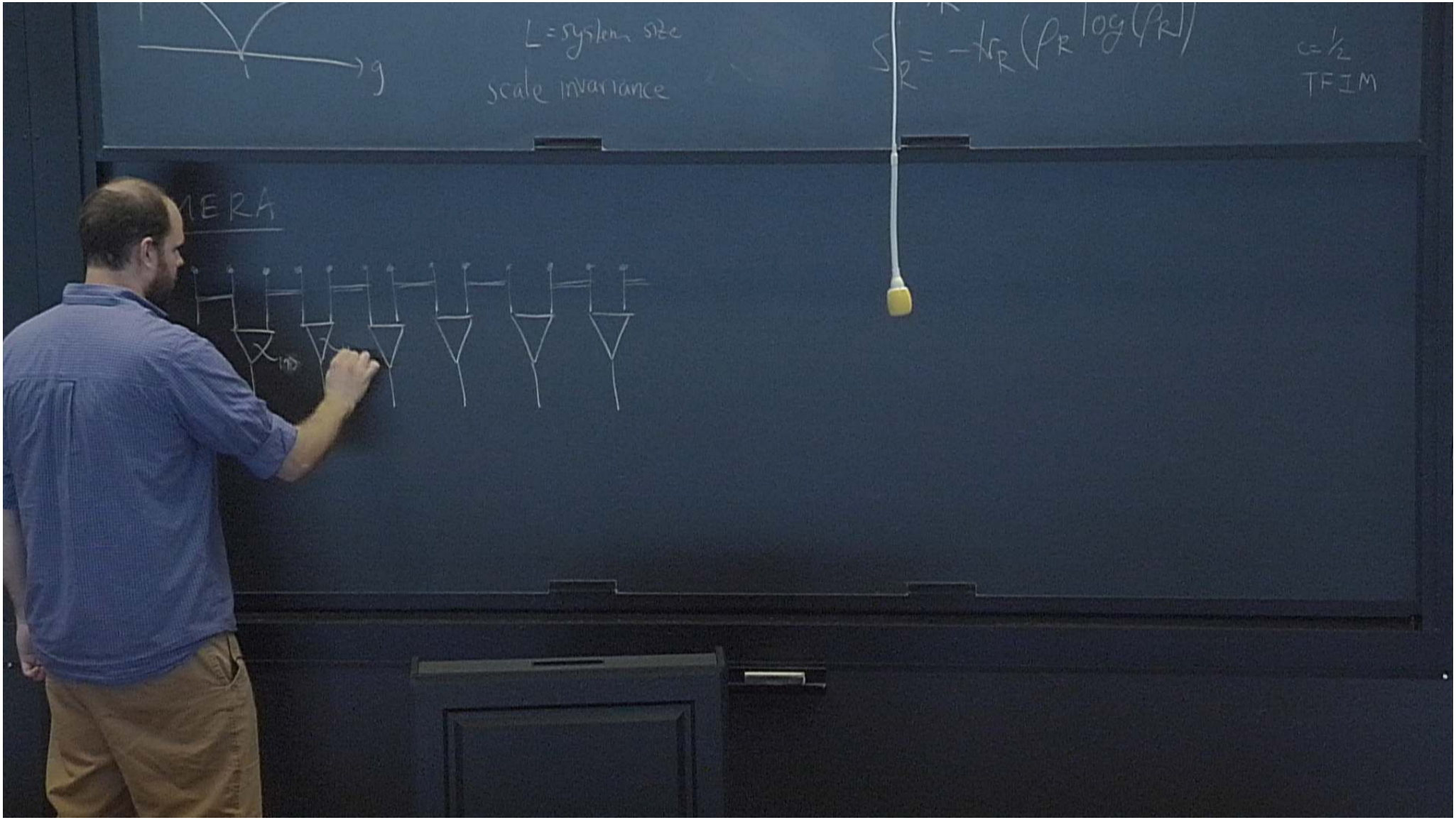
L = system size
scale invariance
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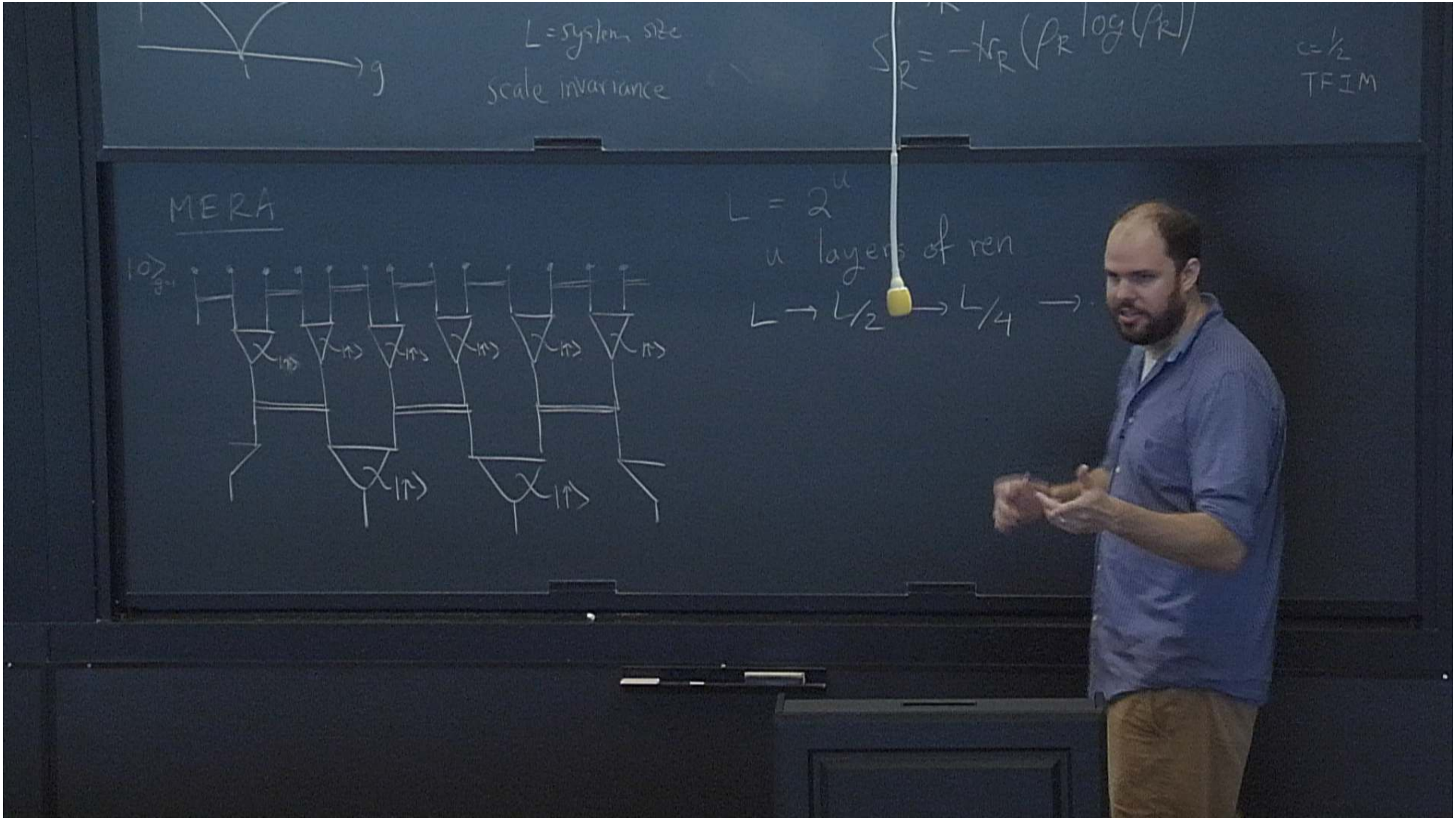
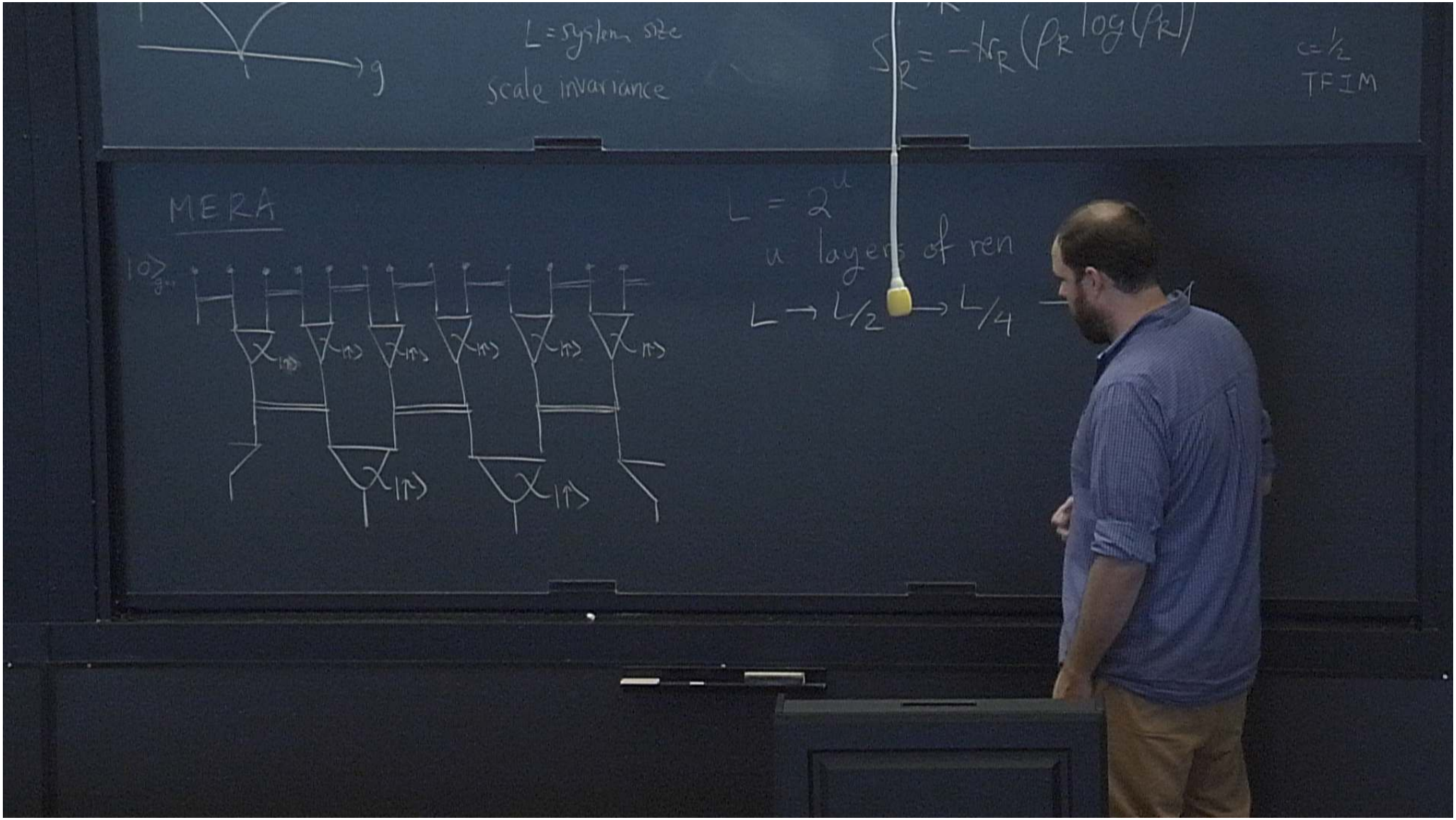
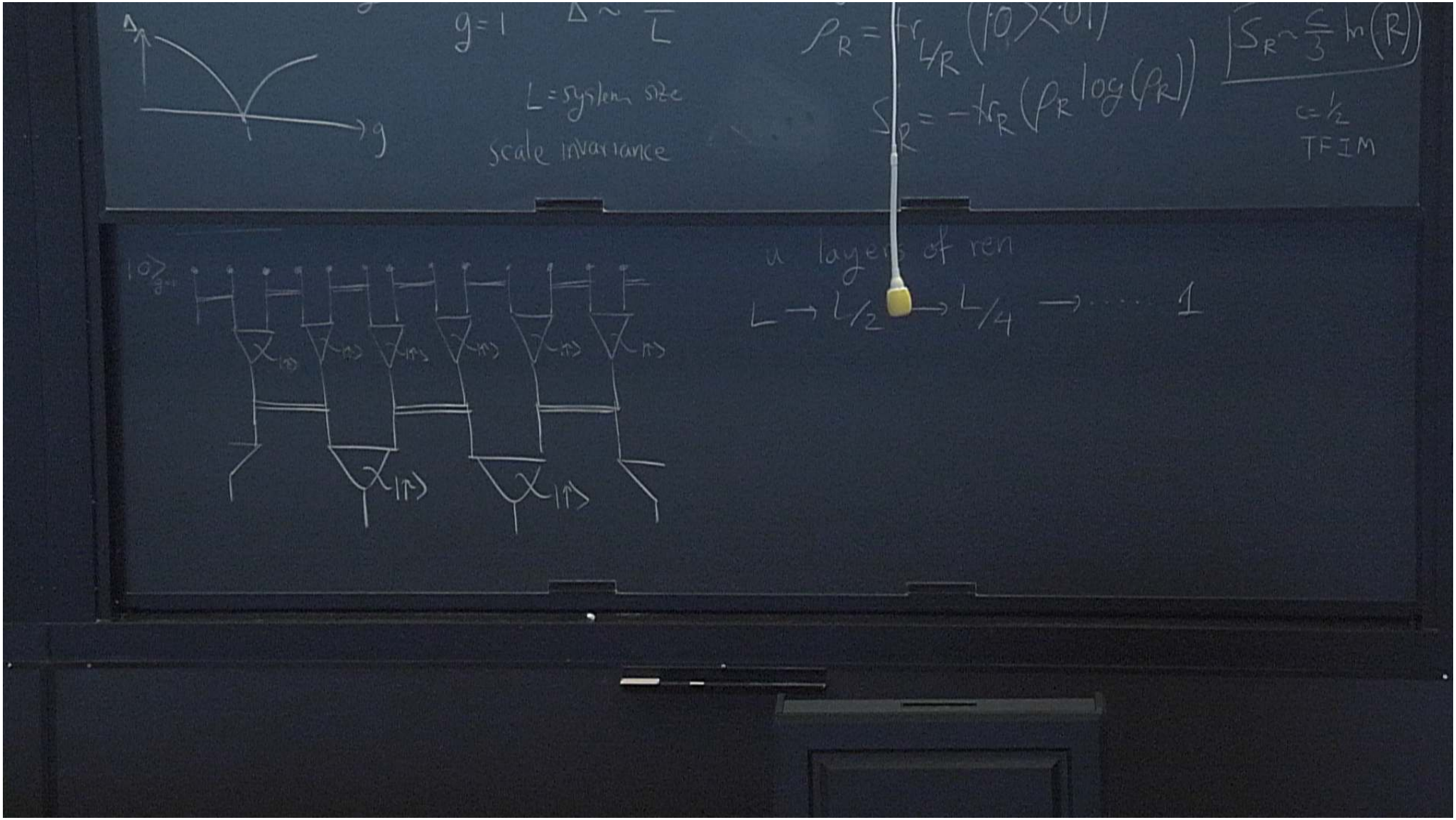
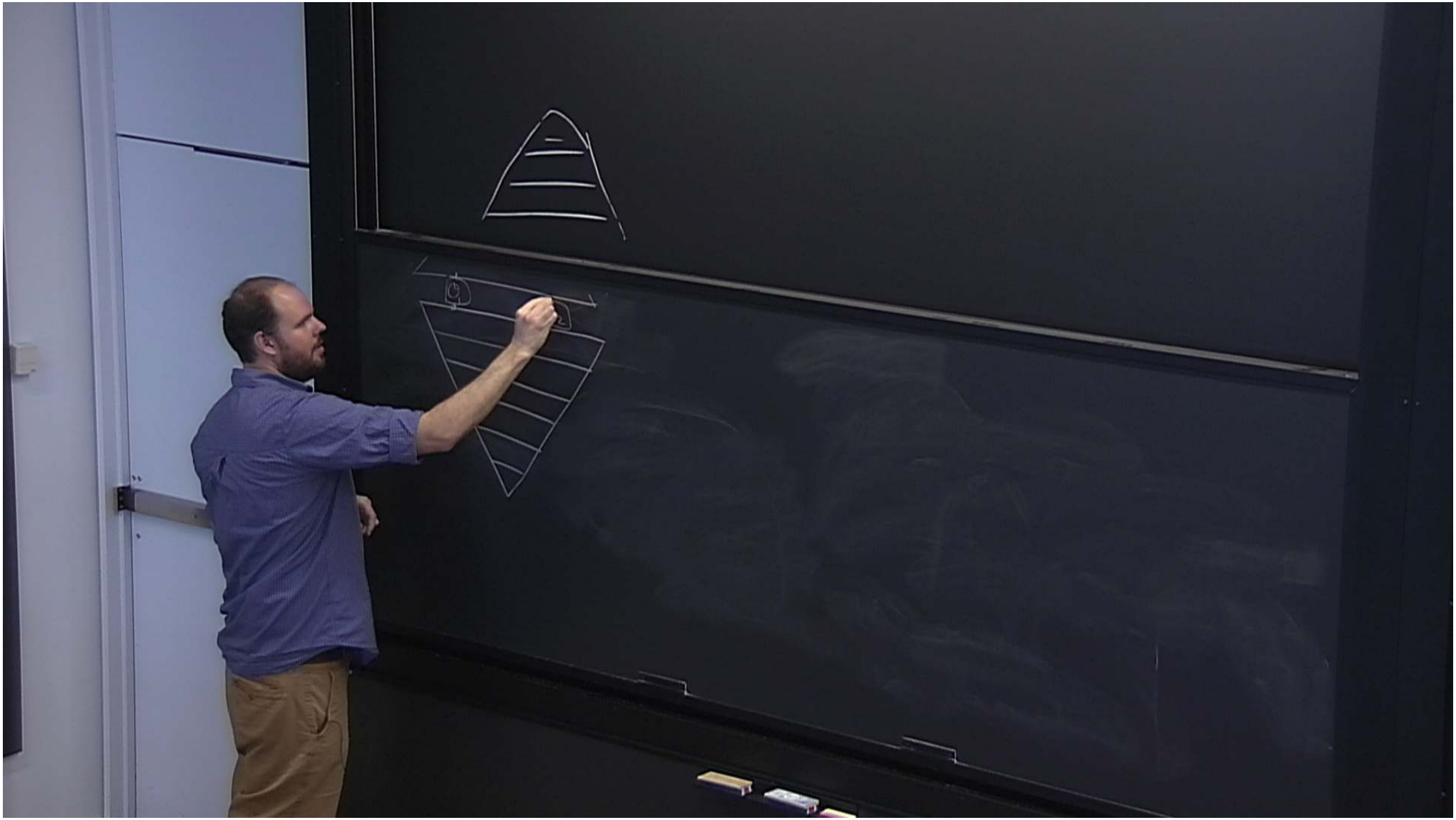
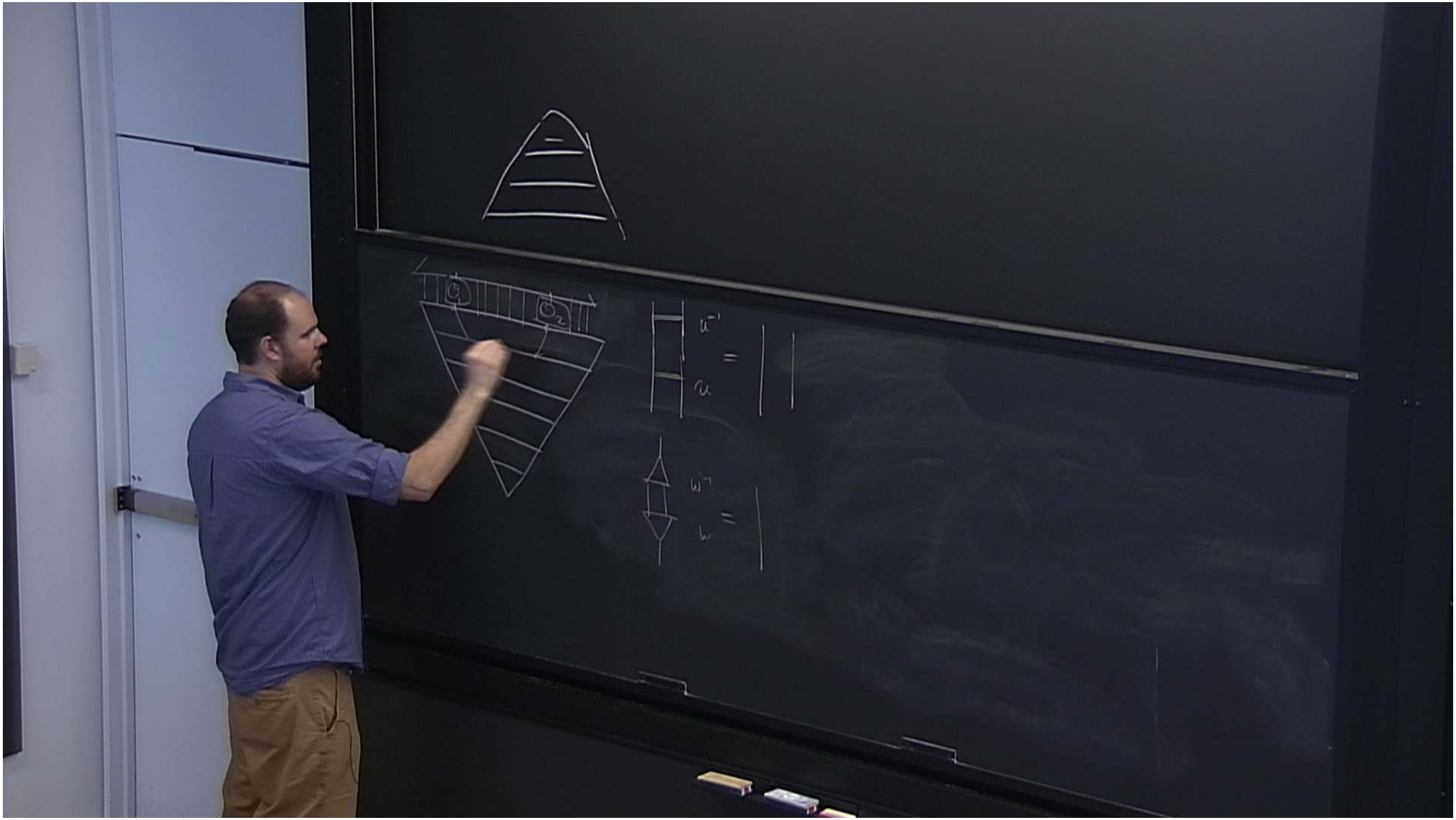
c = ½
TFIM
MERA

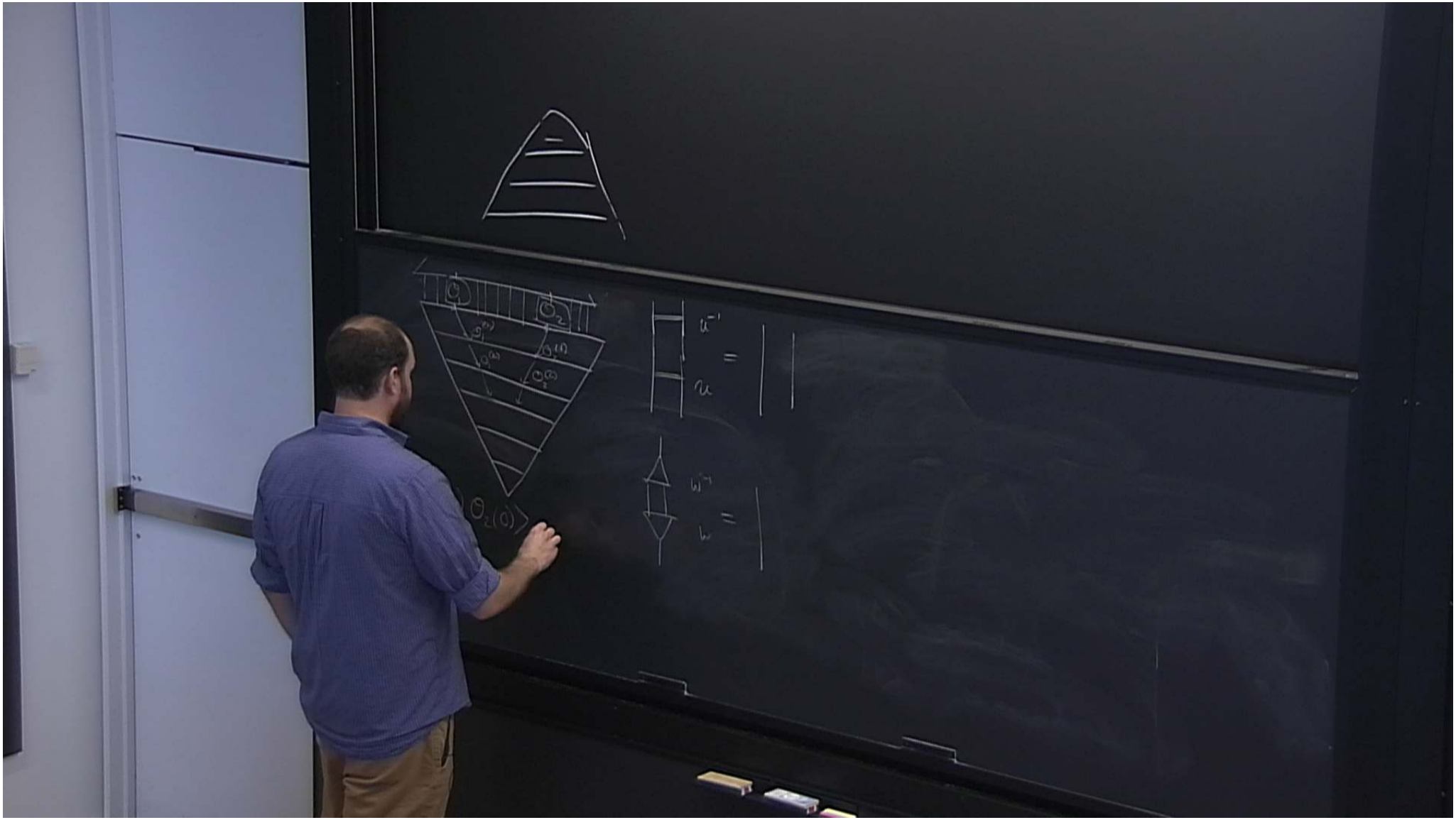

L = system size
scale invariance
$S_R = -\mathrm{tr}_R(\rho_R \log(\rho_R))$
c = 1/2
TFIM
MERA
$L = 2^u$
u layers of ren
$L \to L/2 \to L/4 \to$

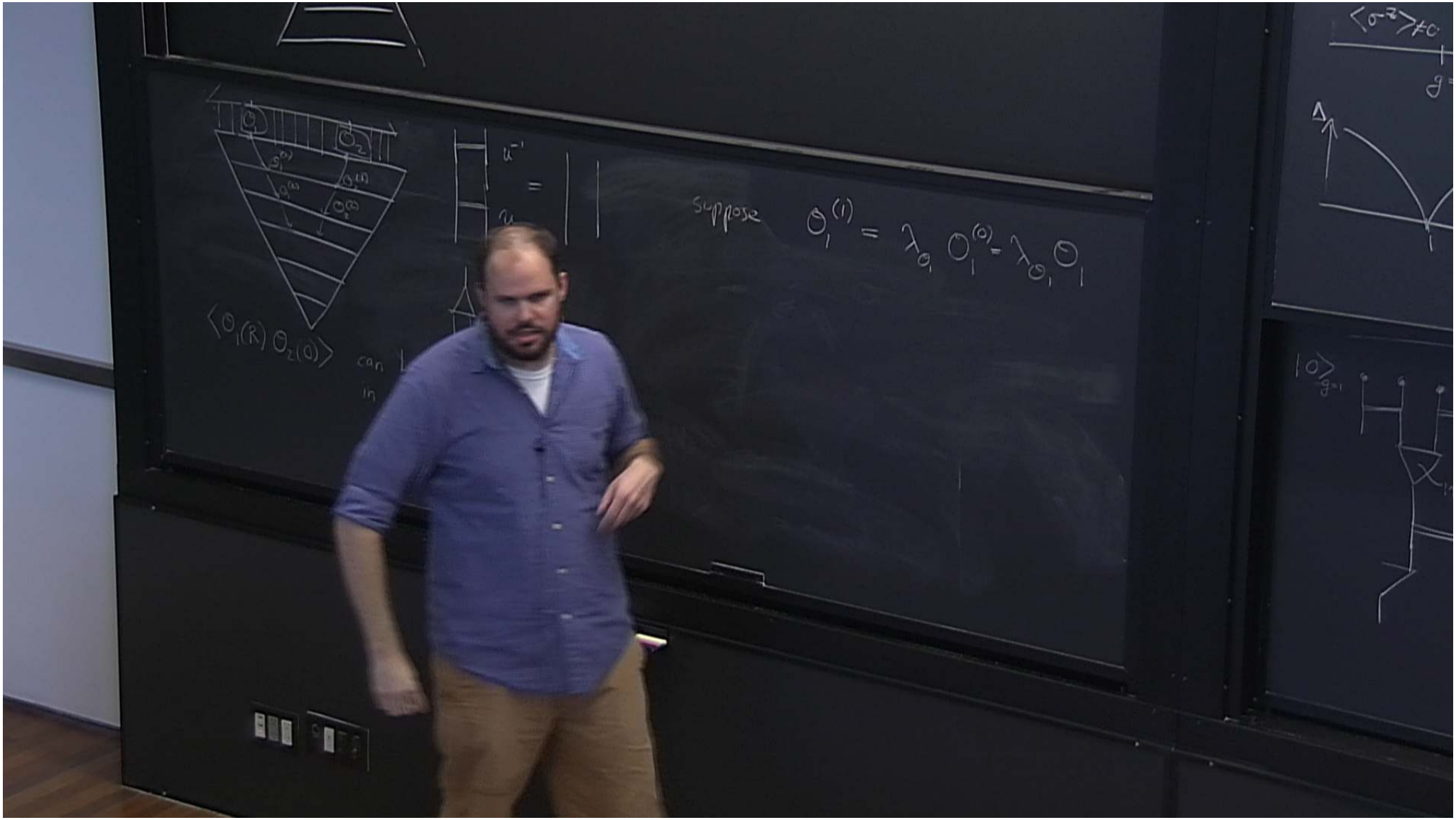

L = system size
scale invariance
g
$S_R = -\mathrm{tr}_R(\rho_R \log(\rho_R))$
c = ½
TFIM
MERA
$|0\rangle_{g=\infty}$
$L = 2^u$
u layers of ren
$L \to L/2 \to L/4$

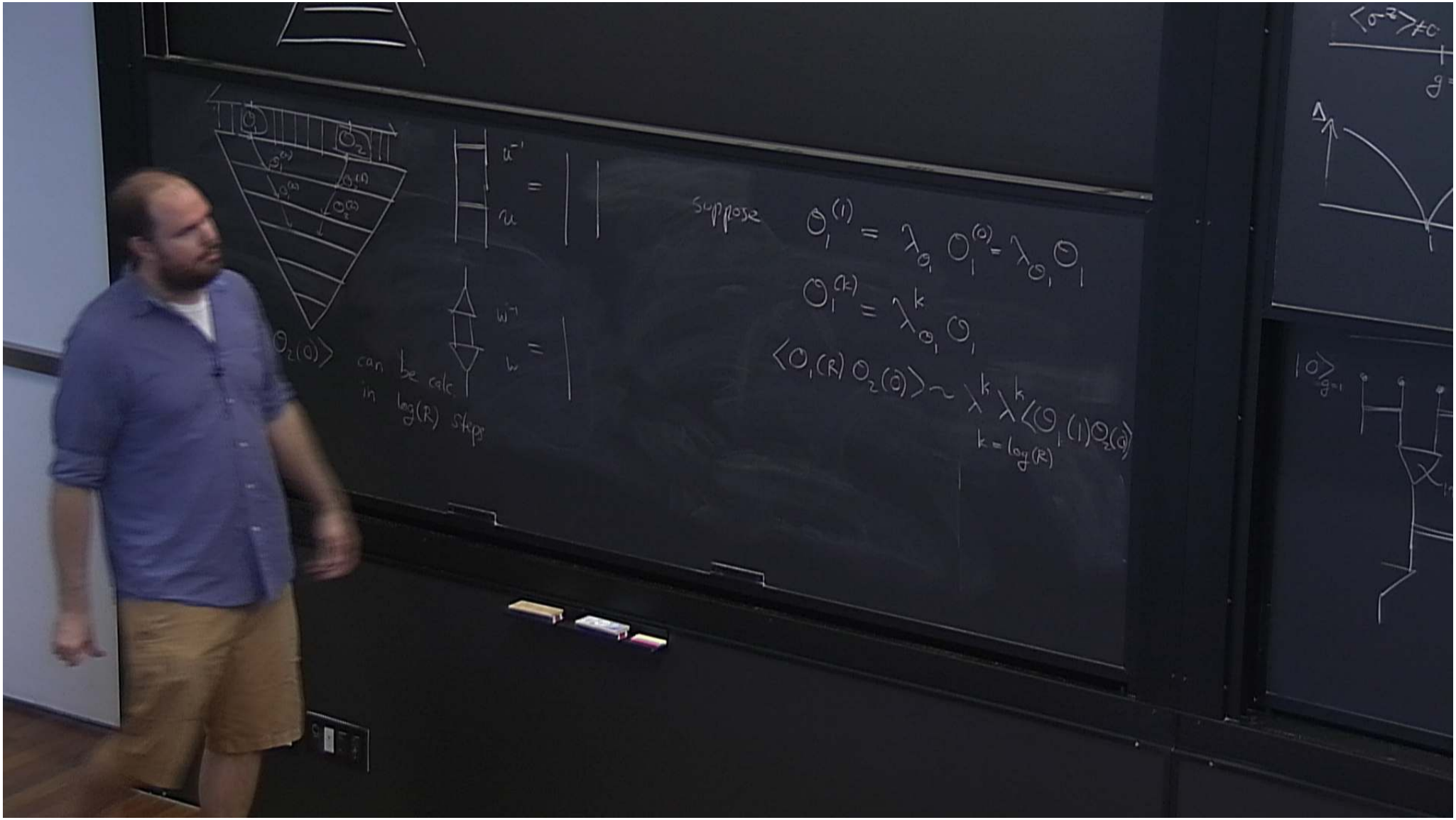

Δ
g
g=1
Δ ~ 1/L
L = system size
scale invariance
ρ_R = tr_{L/R} (|0><0|)
S_R = -tr_R (ρ_R log(ρ_R))
S_R ~ c/3 ln(R)
c = 1/2
TFIM
|0>_g
|↑>
u layers of ren
L → L/2 → L/4 → ··· 1

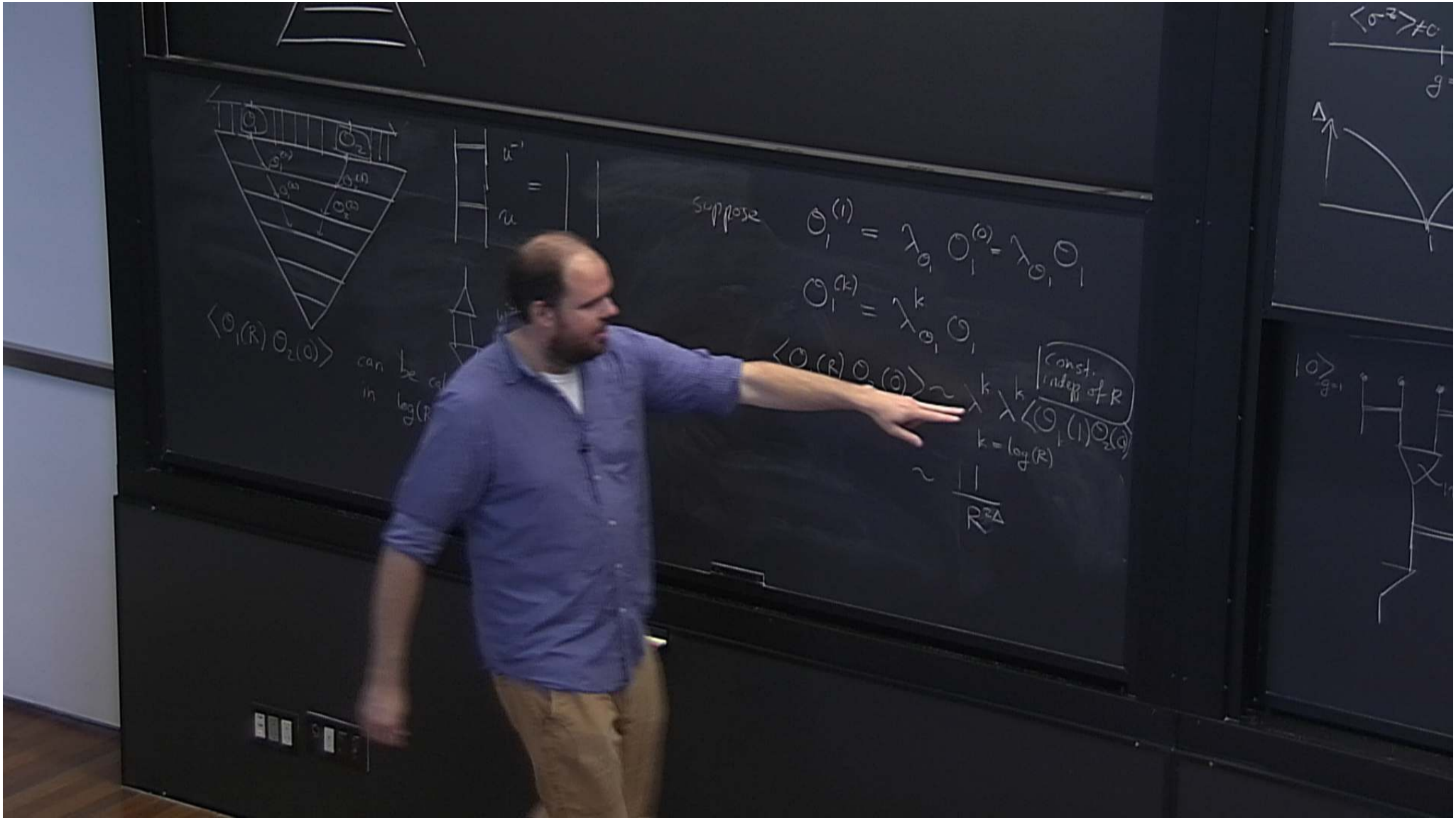


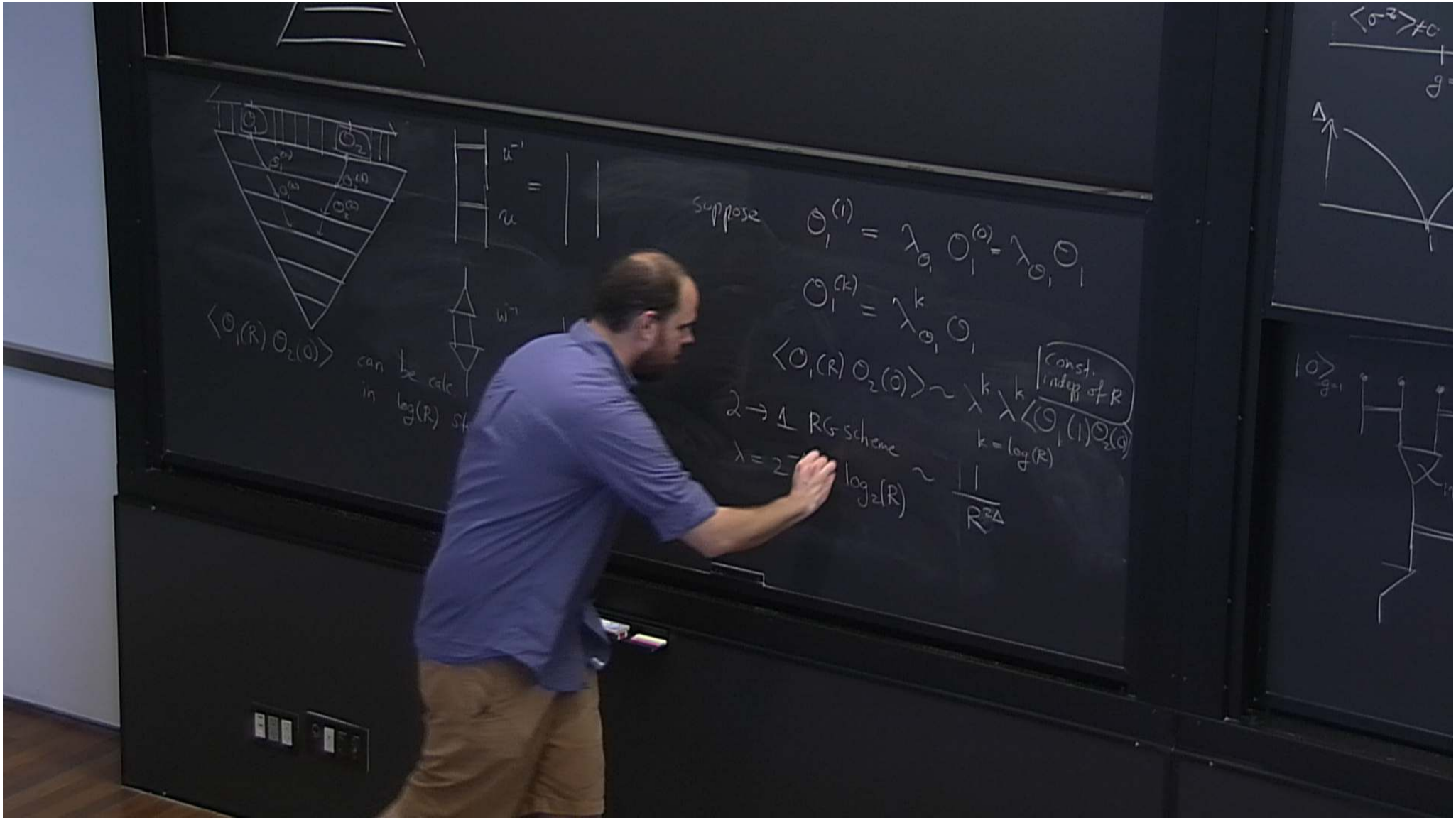


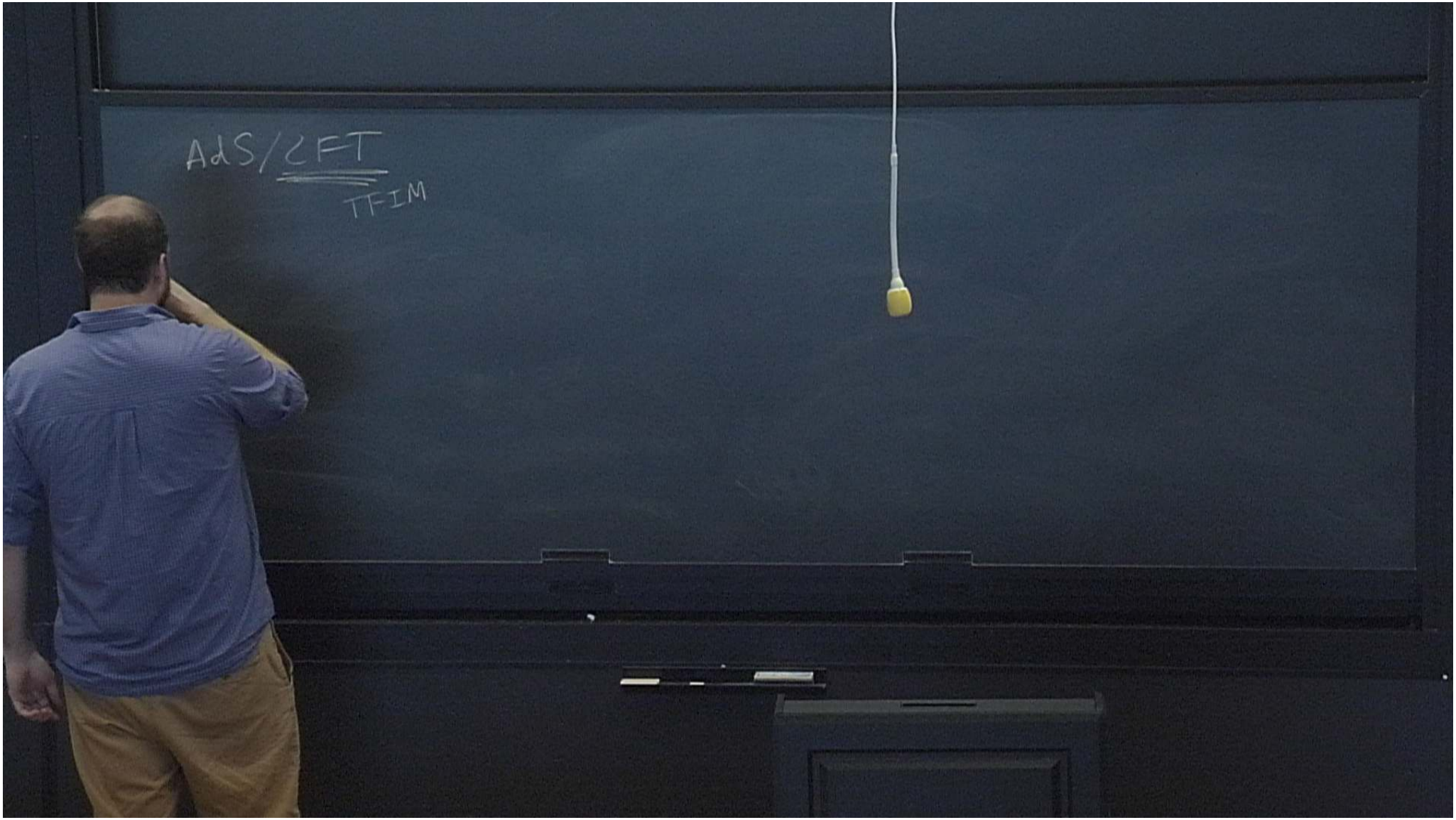


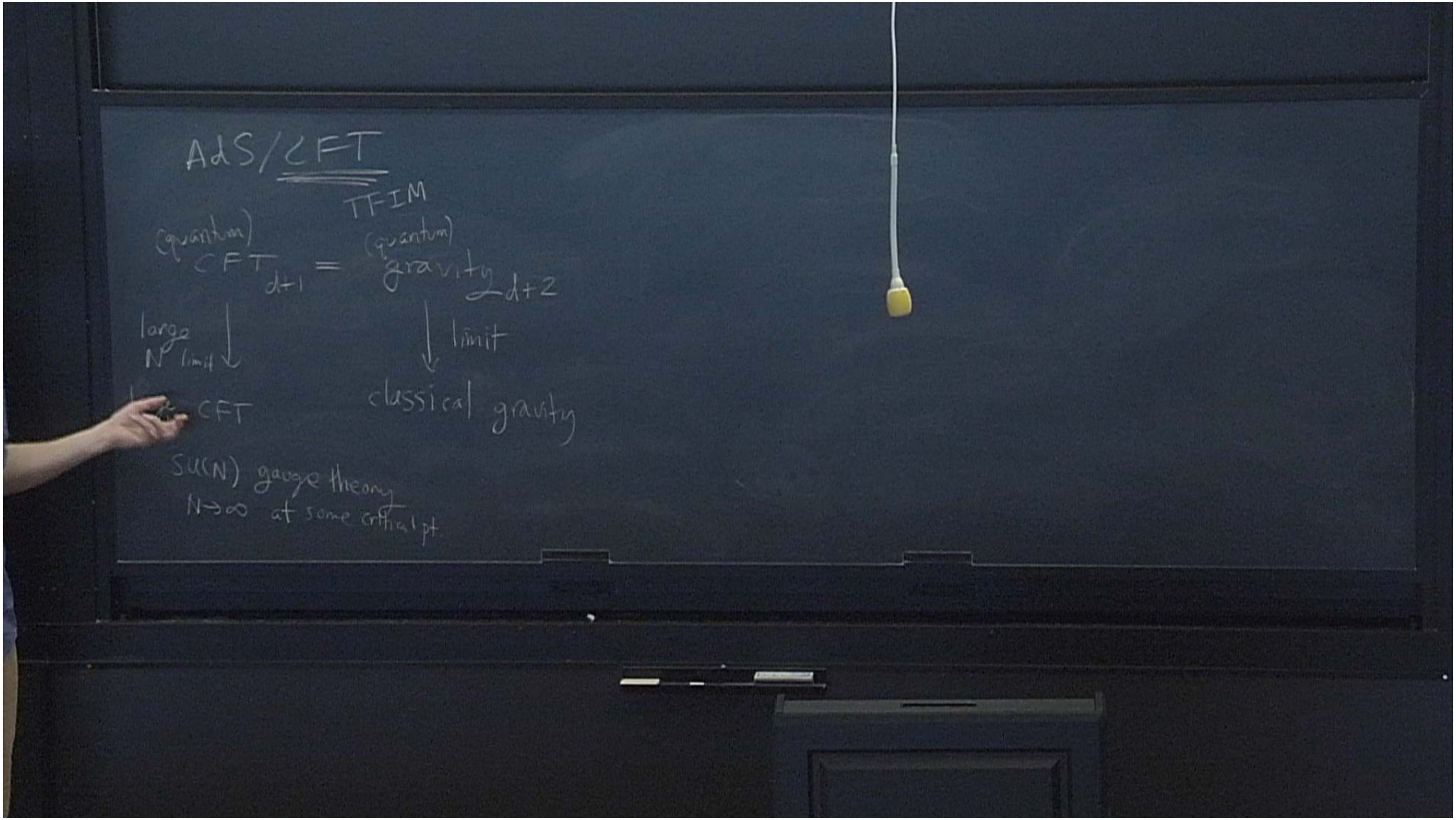

suppose
can

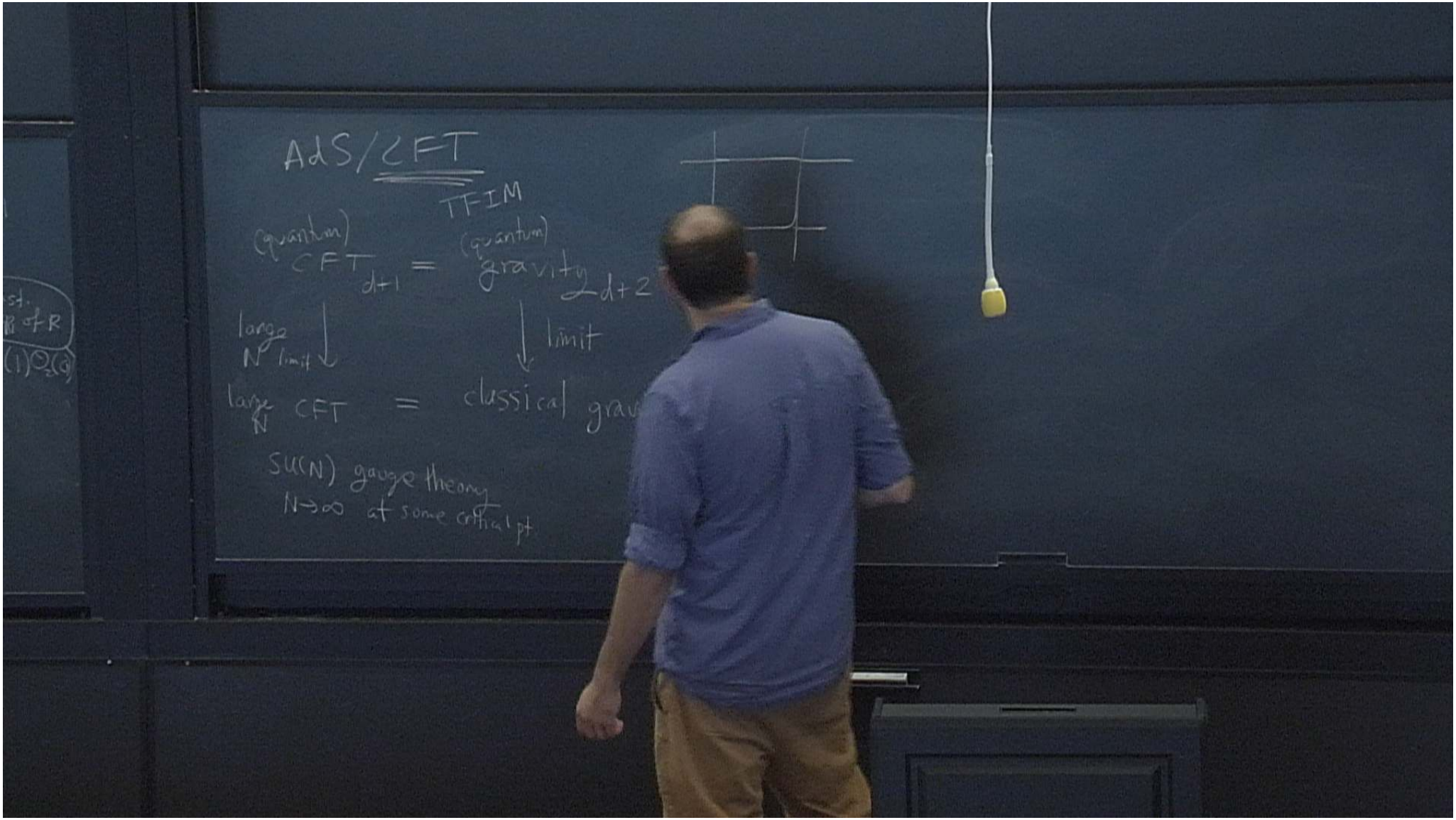

suppose
can be calc.
in log(R) steps

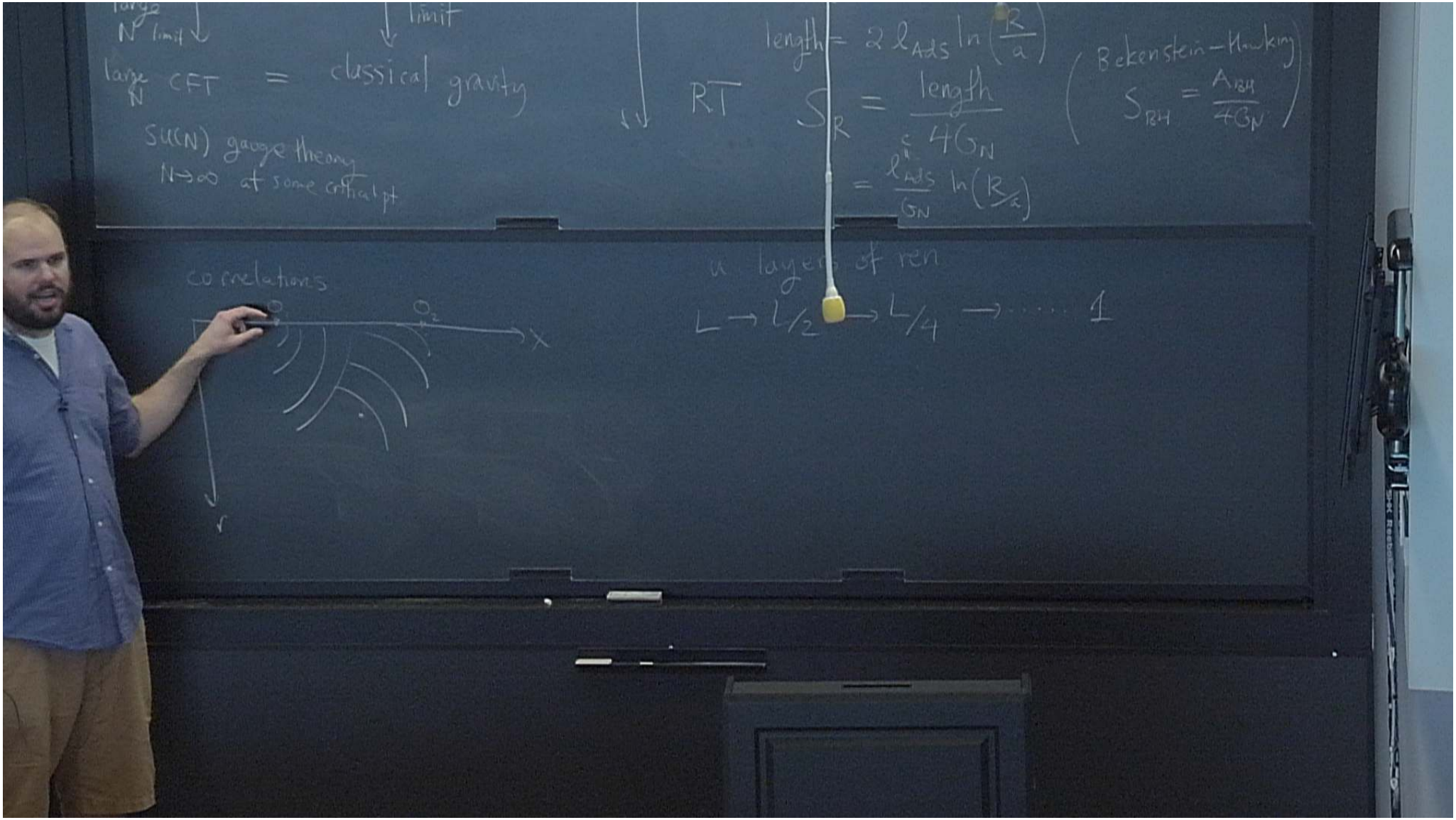

suppose
$\mathcal{O}_1^{(1)} = \lambda_{\mathcal{O}_1} \mathcal{O}_1^{(0)} = \lambda_{\mathcal{O}_1} \mathcal{O}_1$
$\mathcal{O}_1^{(k)} = \lambda_{\mathcal{O}_1}^k \mathcal{O}_1$
$\langle \mathcal{O}_1(R)\, \mathcal{O}_2(0) \rangle$
can be
in log(R
$\langle \mathcal{O}_1(R)\, \mathcal{O}_2(0) \rangle \sim \lambda^k \lambda^k \langle \mathcal{O}_1(1)\, \mathcal{O}_2(0) \rangle$
const. indep of R
$k = \log(R)$
$\sim \frac{1}{R^{2\Delta}}$
$\langle \sigma^z \rangle \neq 0$
Δ
$|0\rangle_{g=1}$

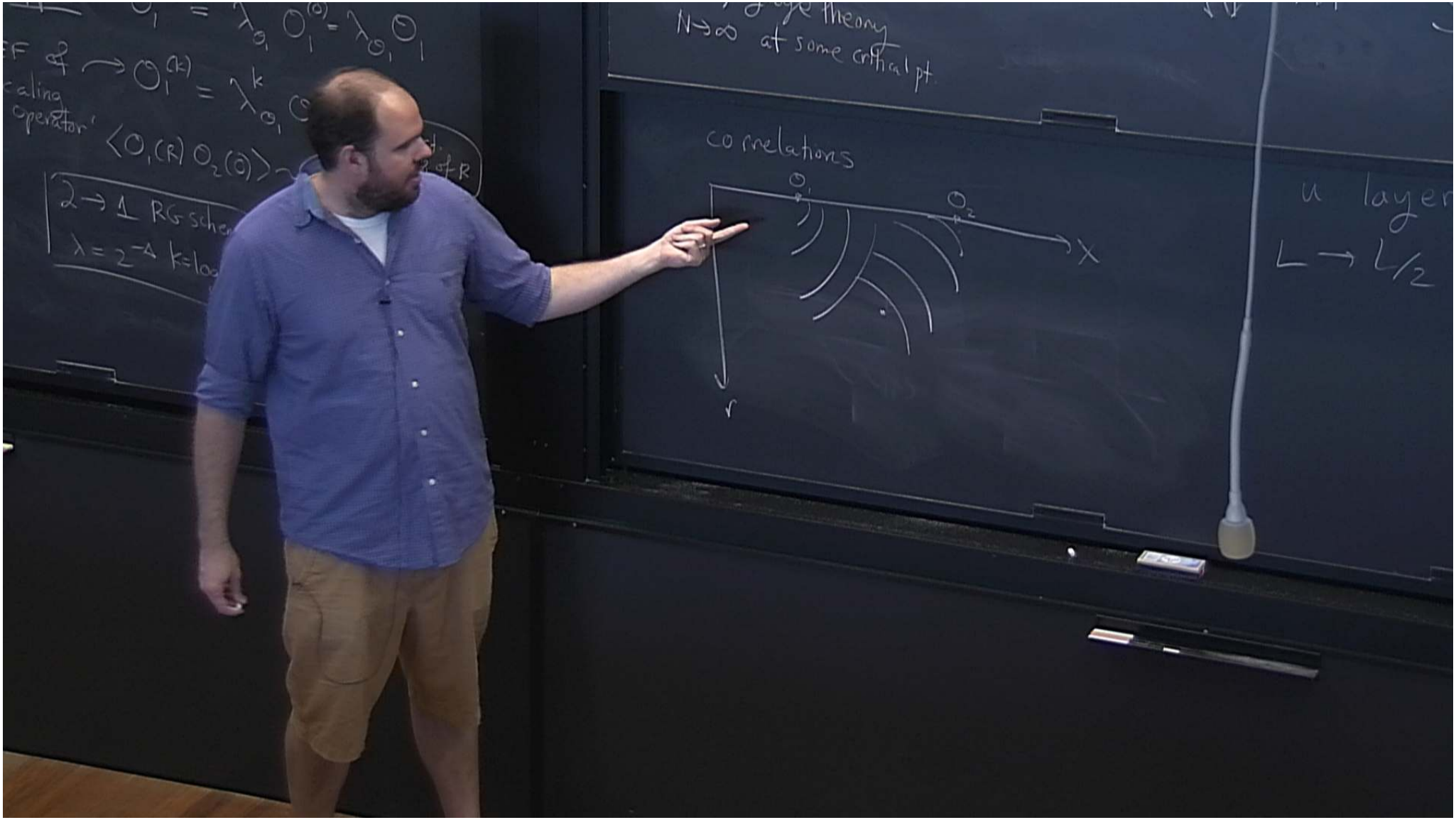

suppose
can be calc
in log(R)
2 → 1 RG scheme
k = log(R)
const. indep of R

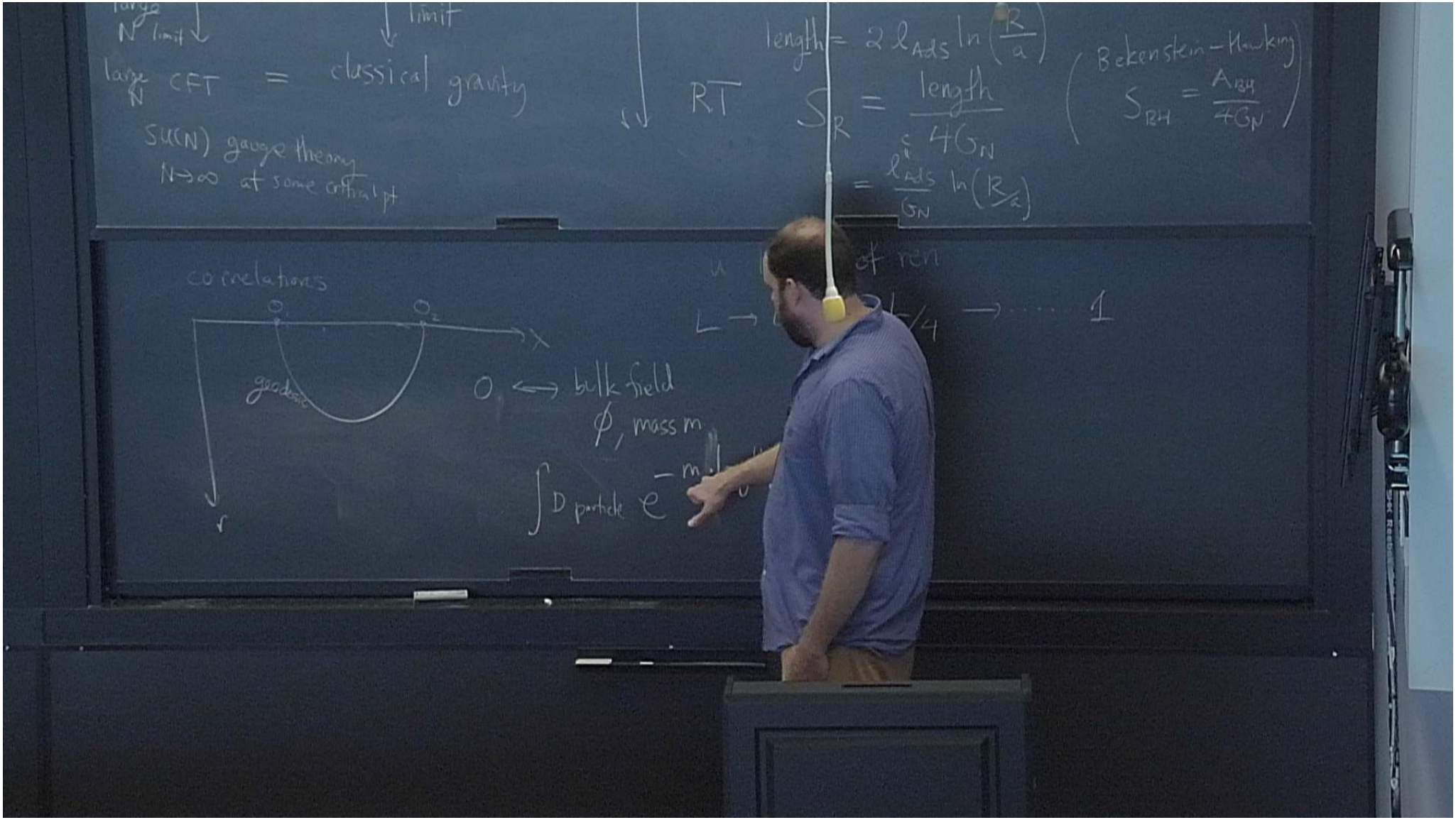

AdS/CFT
TFIM

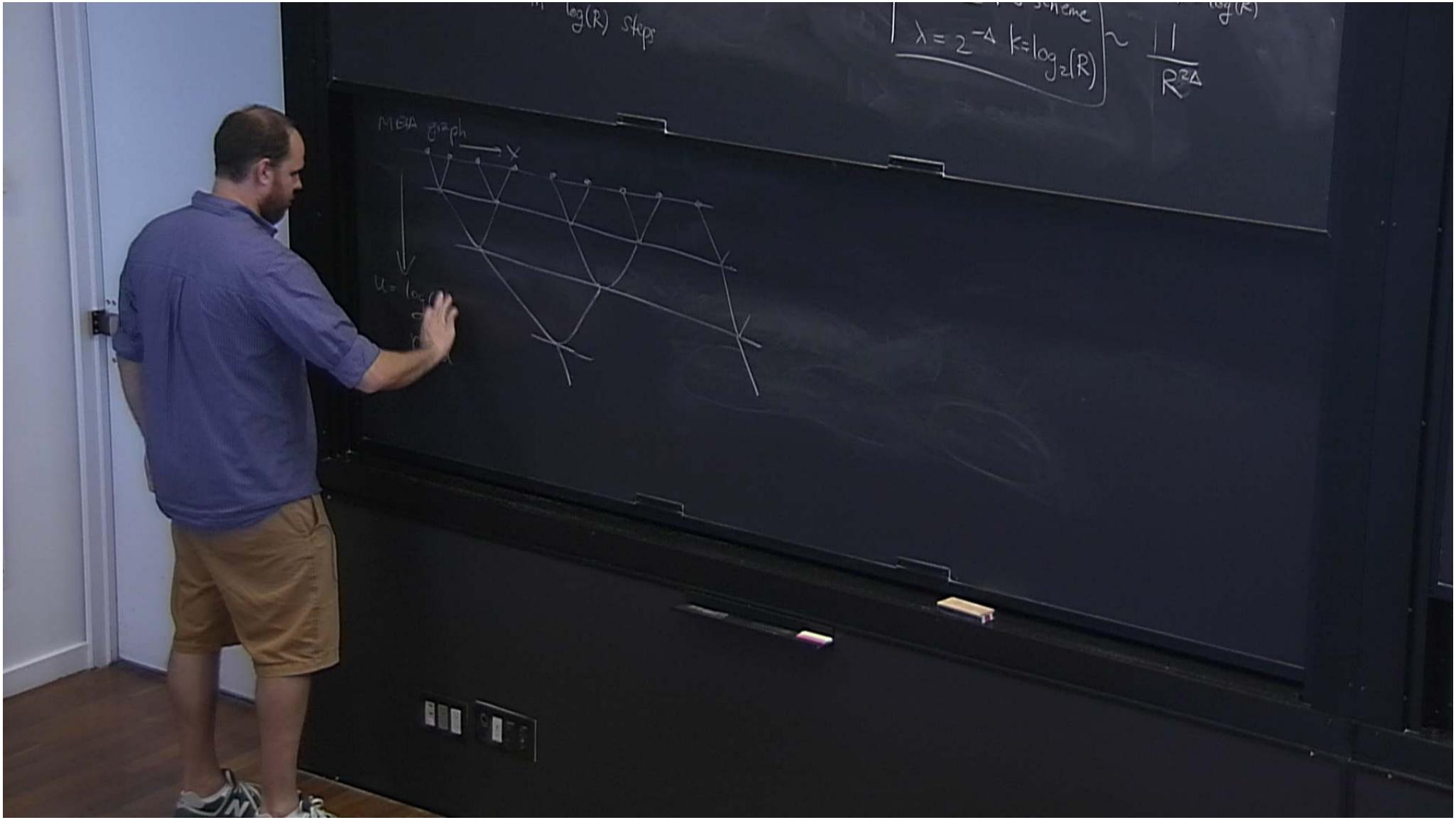

AdS/CFT
TFIM
(quantum) CFT d+1 = (quantum) gravity d+2
large N limit
limit
classical gravity
SU(N) gauge theory
N→∞ at some critical pt.

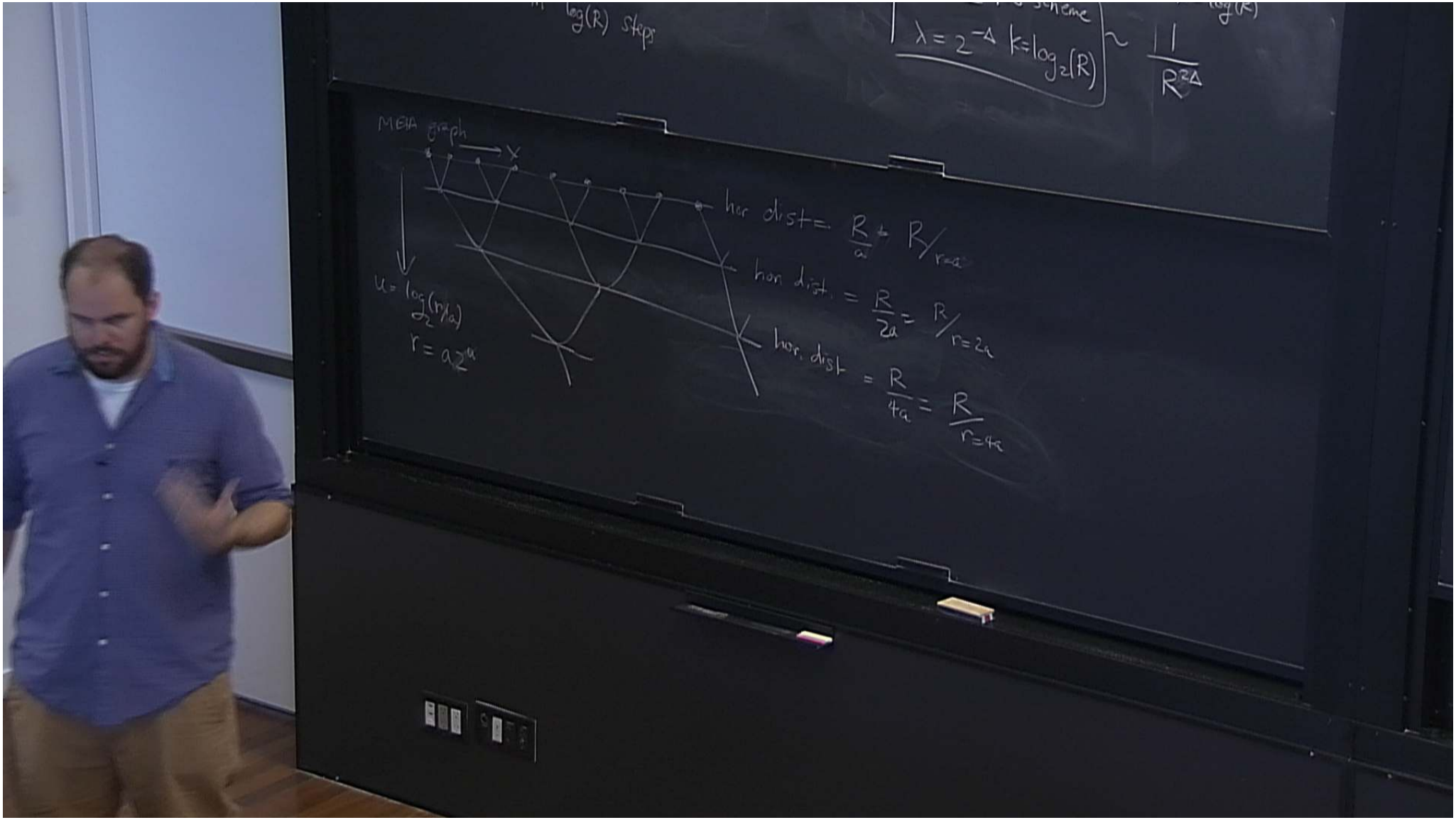

AdS/CFT
TFIM
(quantum) CFT d+1 = (quantum) gravity d+2
large N limit
limit
large N CFT = classical grav
SU(N) gauge theory
N→∞ at some critical pt


large N limit
limit
large N CFT = classical gravity
SU(N) gauge theory
N→∞ at some critical pt
RT
length = 2 ℓ_AdS ln(R/a)
S_R = length / 4G_N
= ℓ_AdS / G_N ln(R/a)
Bekenstein-Hawking
S_BH = A_BH / 4G_N
correlations
O1
O2
x
r
u layers of ren
L → L/2 → L/4 → ···· 1


N→∞ at some critical pt.
correlations
O1
O2
X
r
L → L/2


large N limit
limit
large N CFT = classical gravity
SU(N) gauge theory
N→∞ at some critical pt
RT
length = 2 ℓ_Ads ln(R/a)
S_R = length / 4G_N
= ℓ_Ads / G_N ln(R/a)
Bekenstein-Hawking
S_BH = A_BH / 4G_N
correlations
geodesic
O ⟷ bulk field
φ, mass m
∫ D particle e
1


log(R) steps
$\lambda = 2^{-A}$ $k = \log_2(R)$
$\sim \frac{1}{R^{2A}}$
MERA graph
x


log(R) steps
$\lambda = 2^{-\Delta}$ $k = \log_2(R)$
$\sim \frac{1}{R^{2\Delta}}$
MERA graph
X
hor dist = $\frac{R}{a} + R/_{r=a}$
hor dist. = $\frac{R}{2a} = R/_{r=2a}$
hor dist = $\frac{R}{4a} = \frac{R}{r=4a}$
$u = \log_2(r/a)$
$r = a\,2^u$