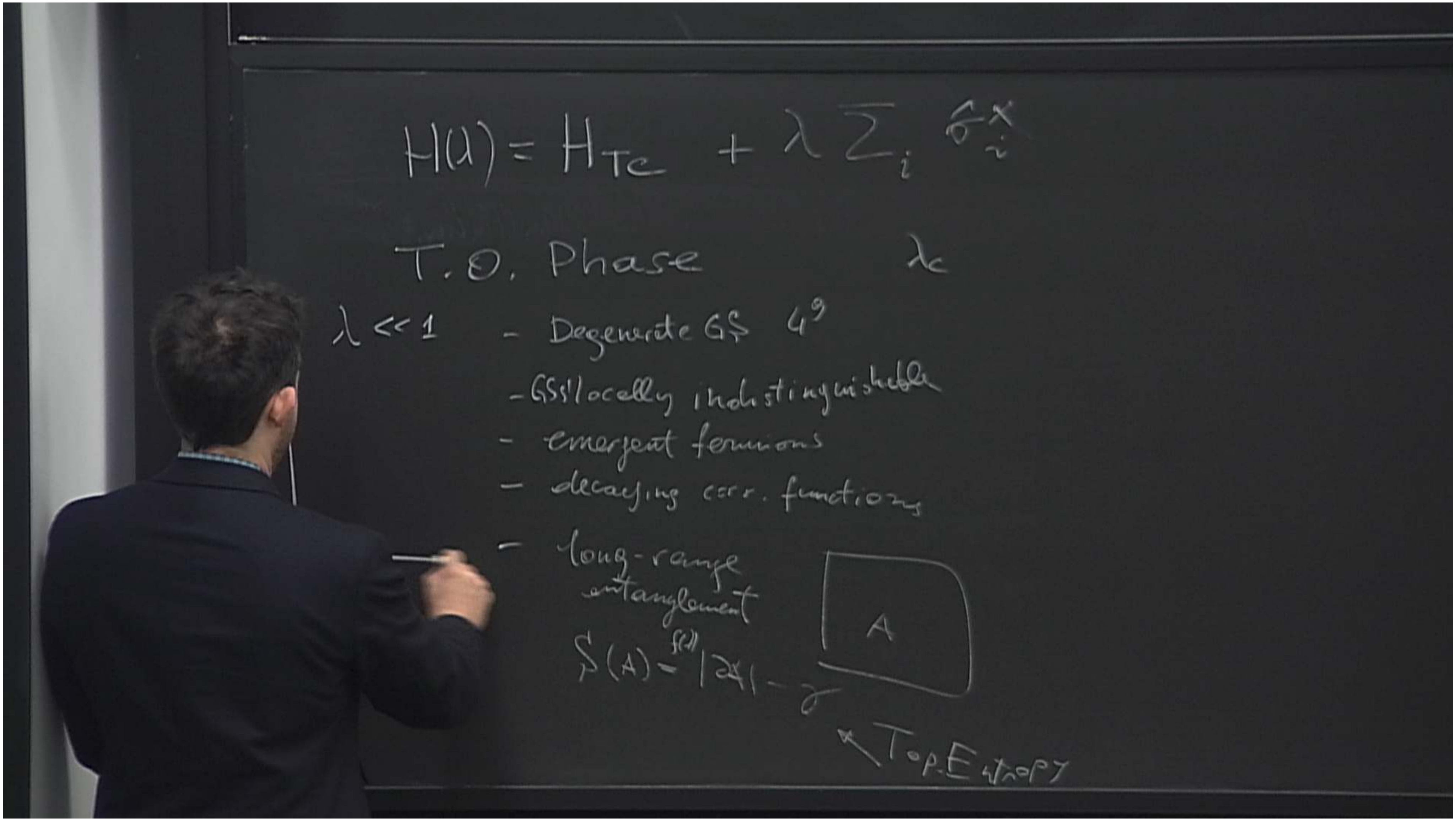
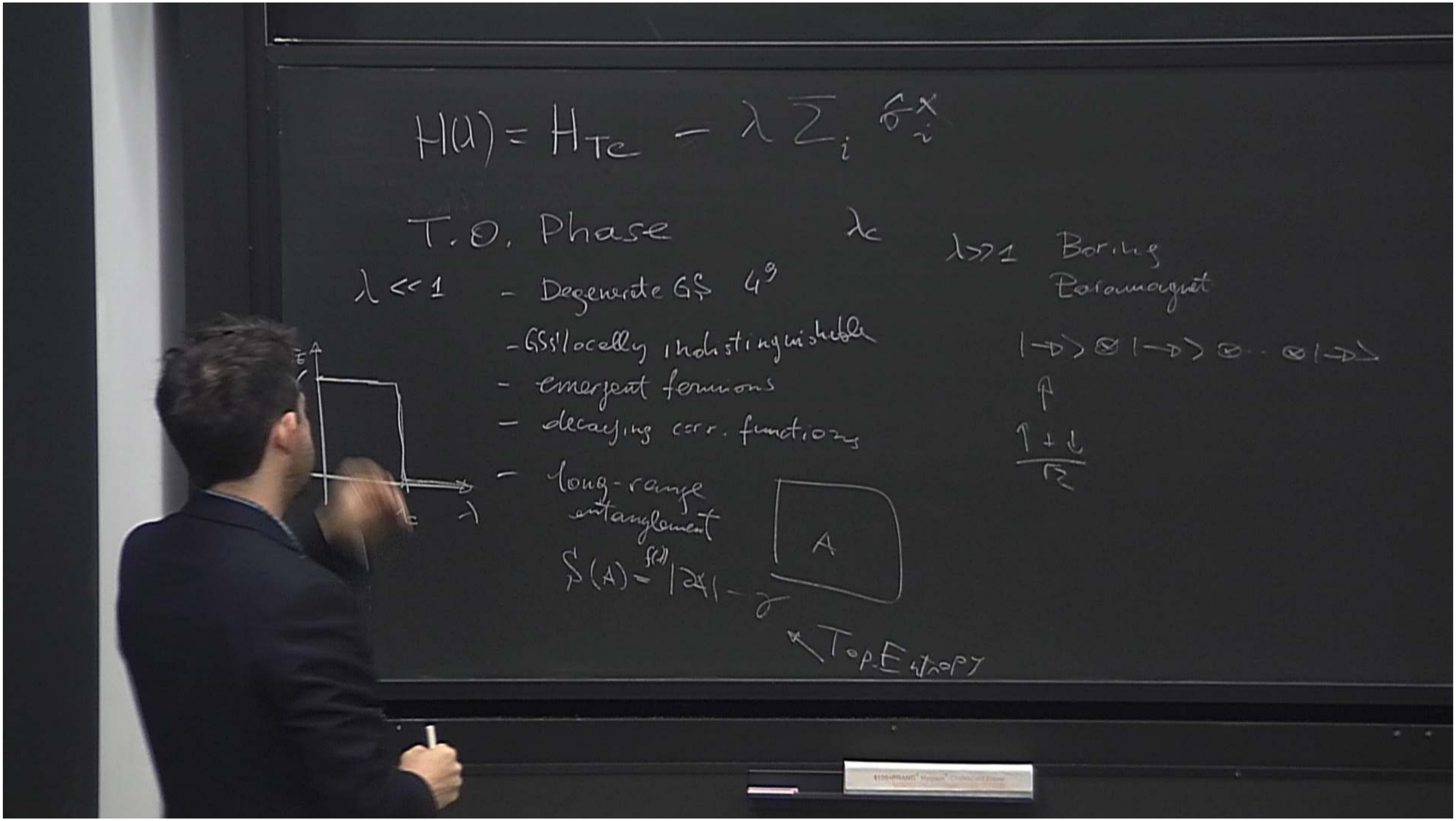
Title: 13/14 PSI - Condensed Matter Review - Lecture 14

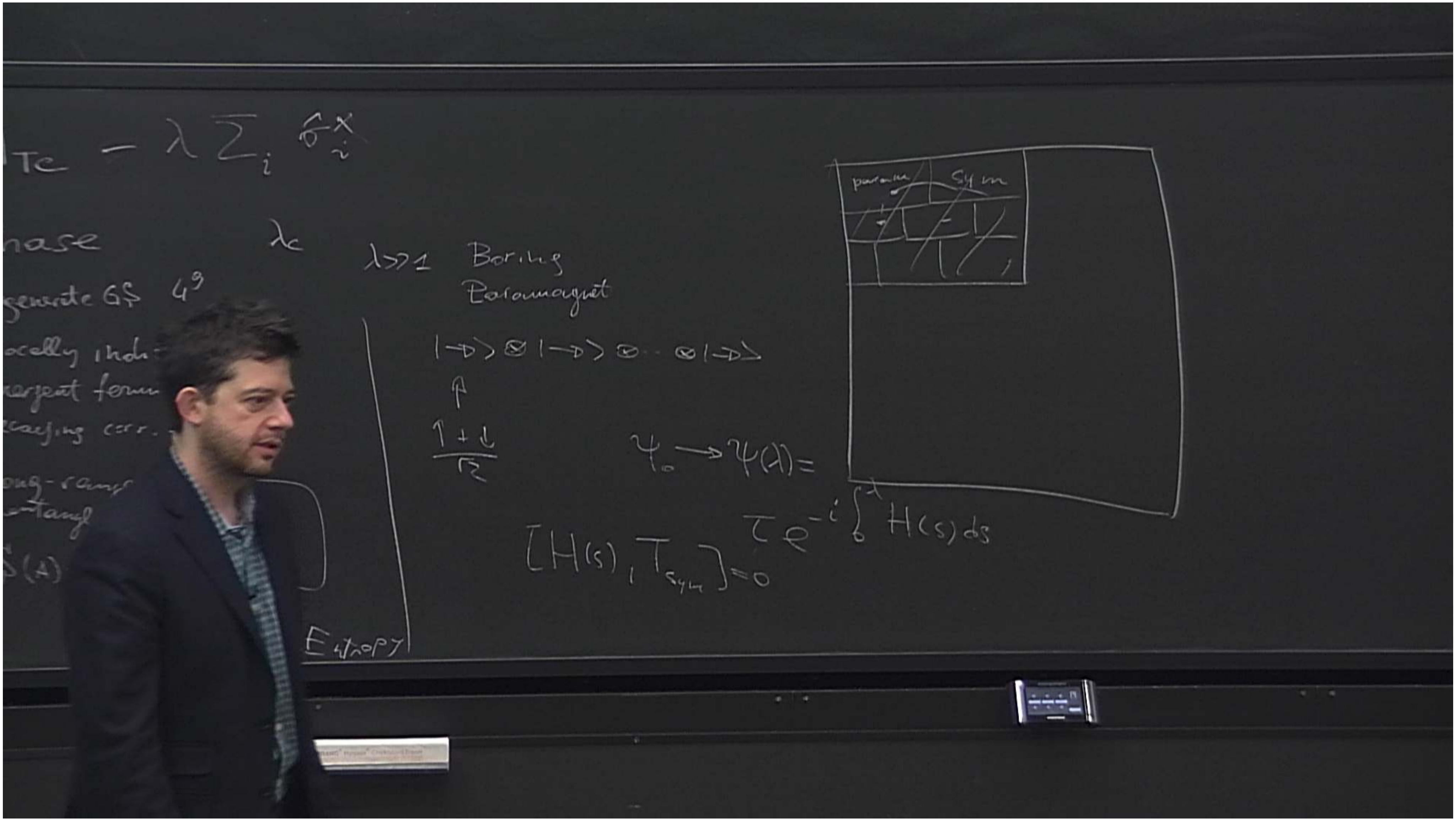
Date: Feb 14, 2014 09:00 AM

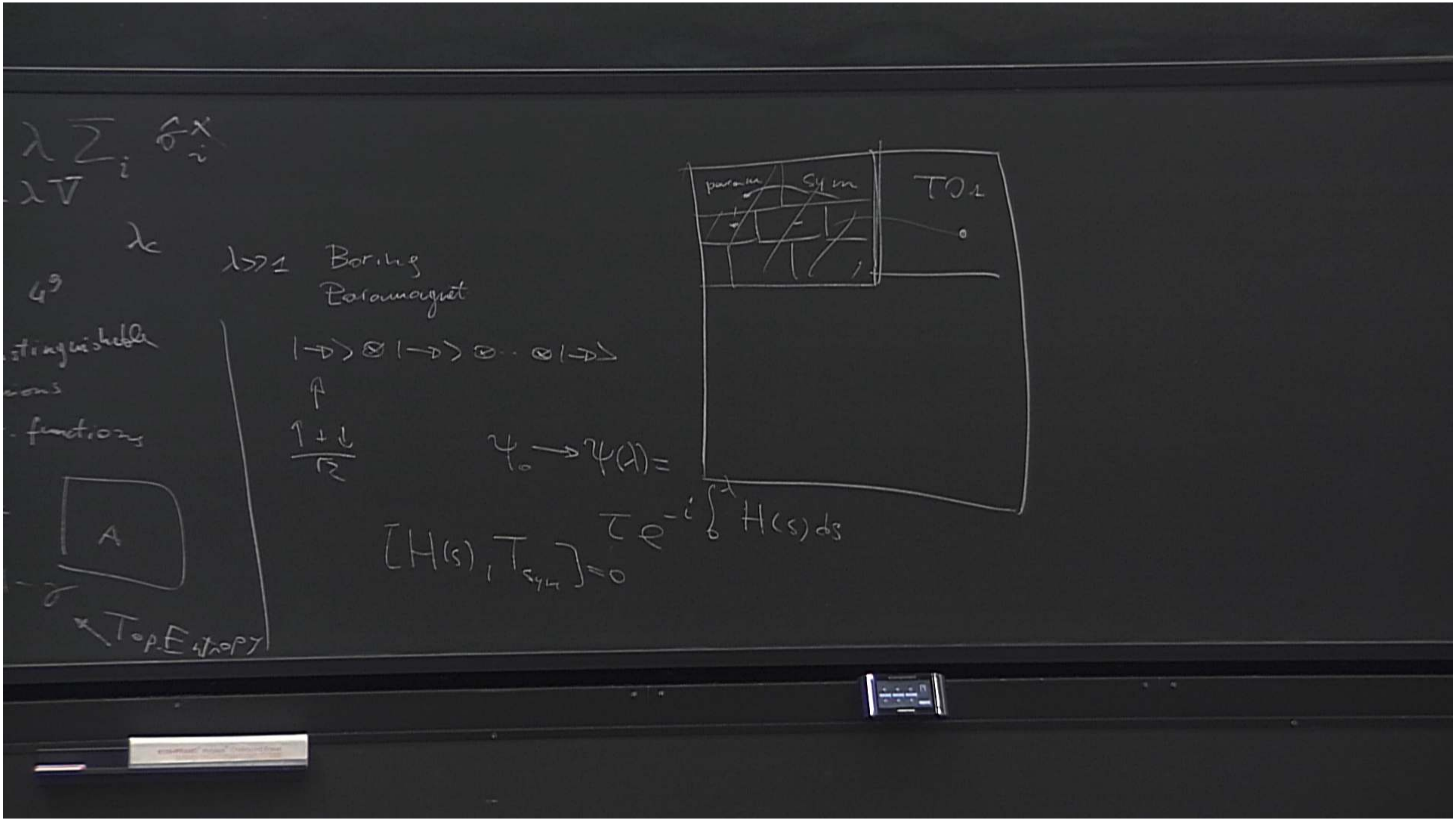
URL: http://pirsa.org/14020107

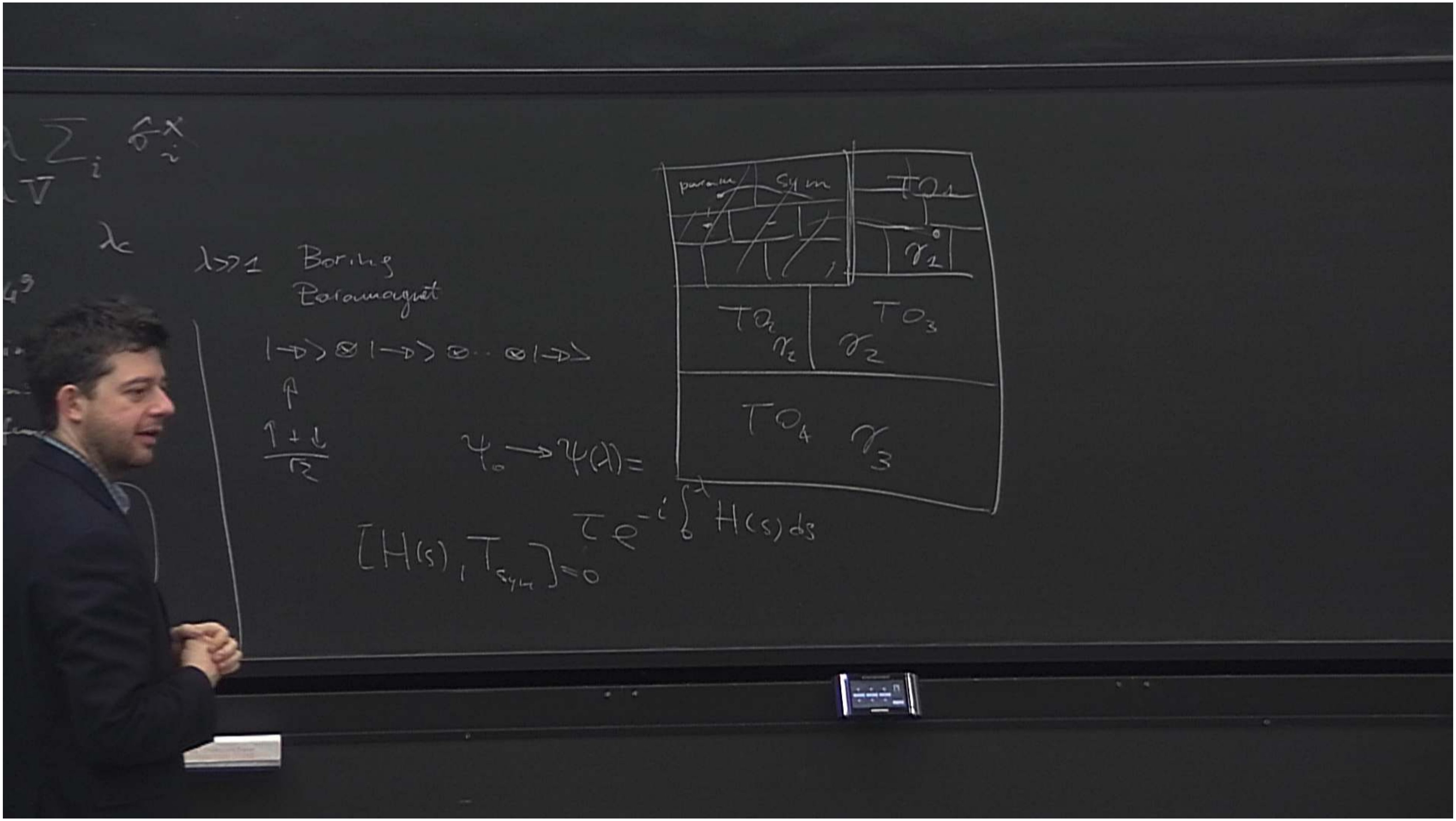
Abstract:

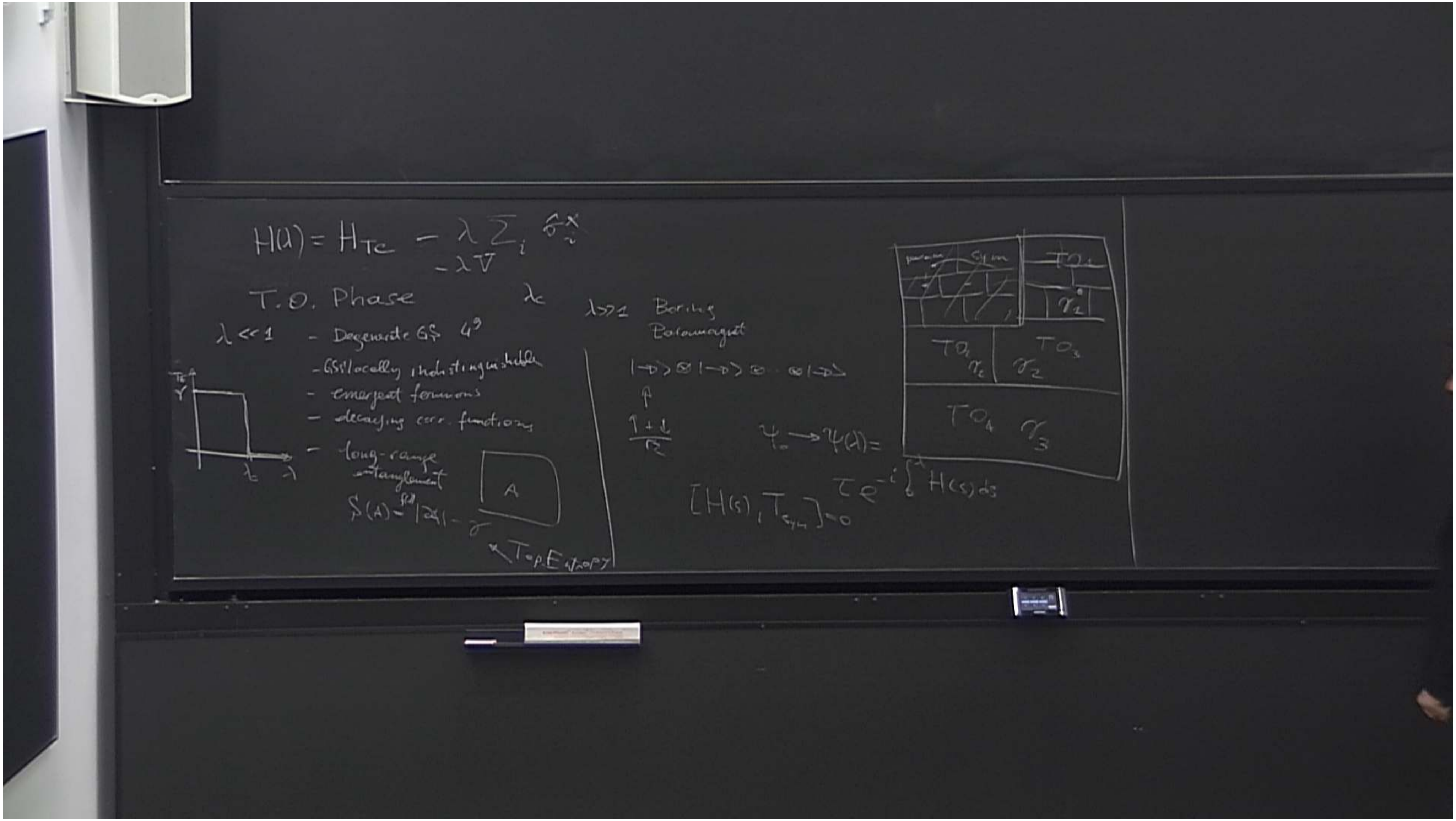

H(λ) = H_TC + λ Σ_i σ_i^x
T.O. Phase
λ_c
λ << 1
- Degenerate GS 4^g
- GS's locally indistinguishable
- emergent fermions
- decaying corr. functions
- long-range entanglement
S(A) = f(λ)|∂A| - γ
A
Top. Entropy


H(λ) = H_TC − λ Σ_i σ̂^x_i
T.O. Phase
λ_c
λ>>1 Boring
Paramagnet
λ << 1
- Degenerate GS 4^g
- GS's locally indistinguishable
- emergent fermions
- decaying corr. functions
- long-range
entanglement
S(A) = |∂A| − γ
A
Top. Entropy

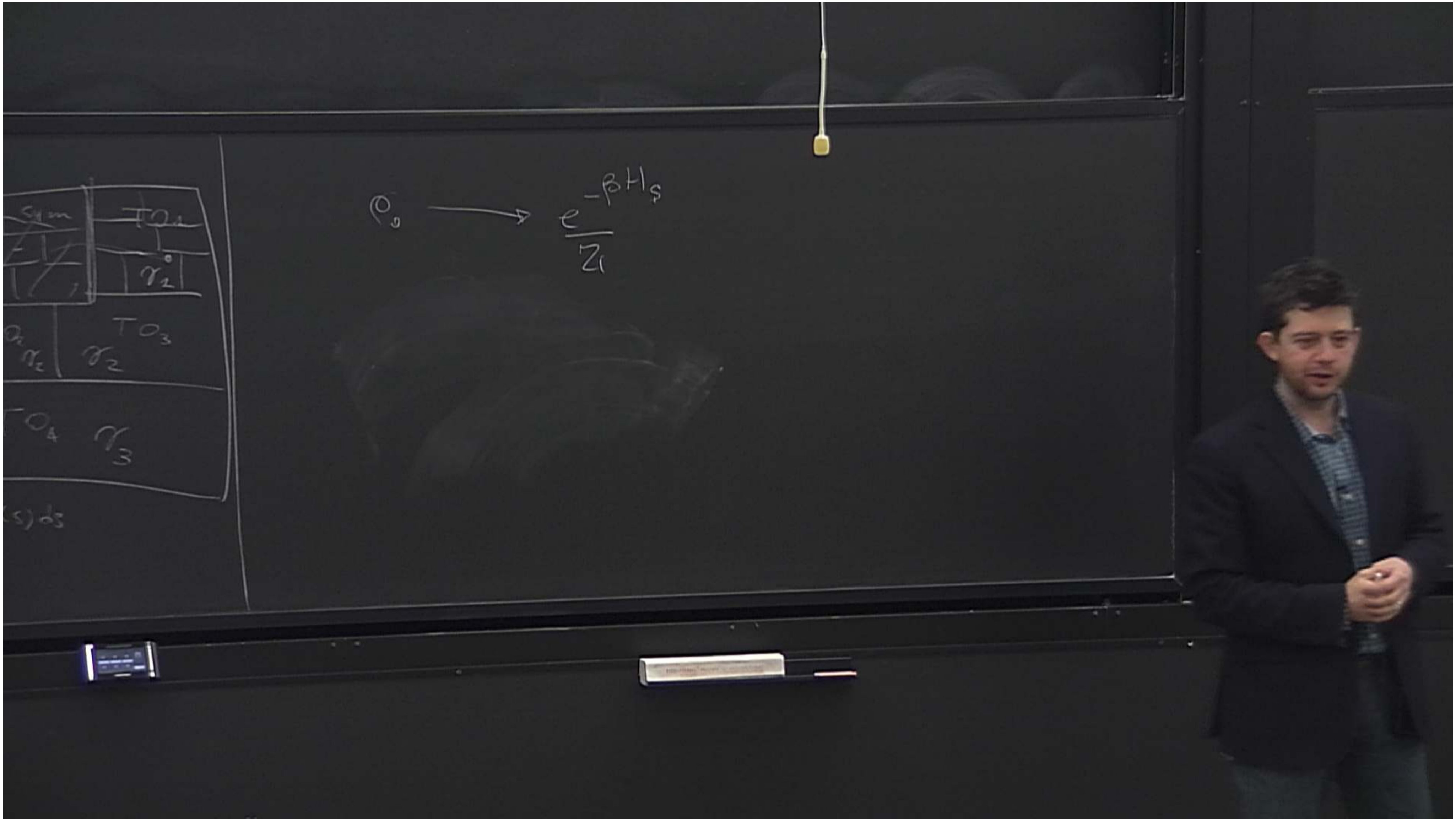

λ >> 1 Boring
Paramagnet
Ψ₀ → Ψ(λ) =
Entropy


λ>>1 Boring
Paramagnet
[H(s), T_sym] = 0
Top Entropy
A
param
sym
TO

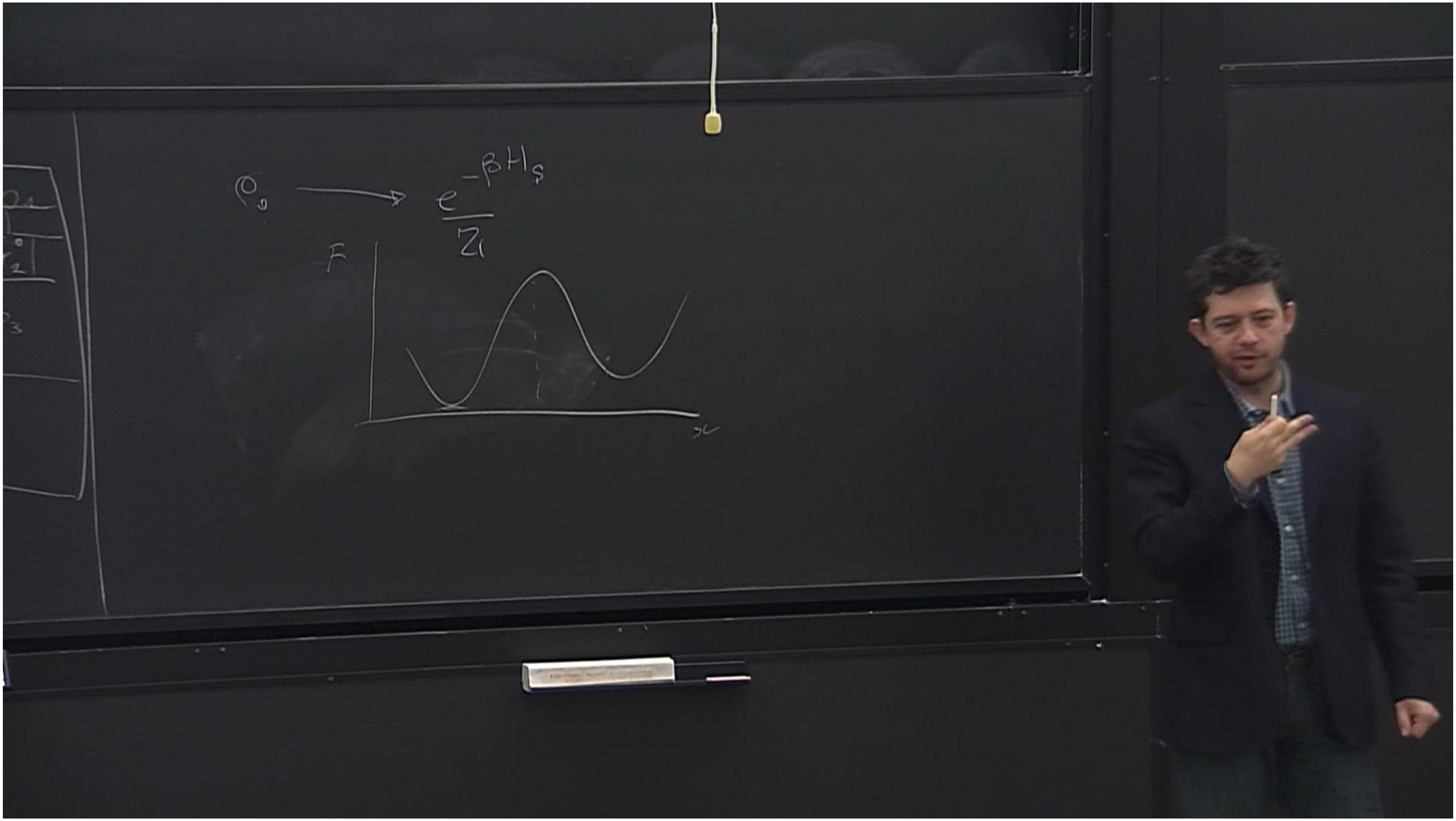

λ>>1 Boring
Paramagnet
para
sym
TO1
TO2
TO3
TO4
Ψ0 → Ψ(λ) =
[H(s), T_sym] = 0

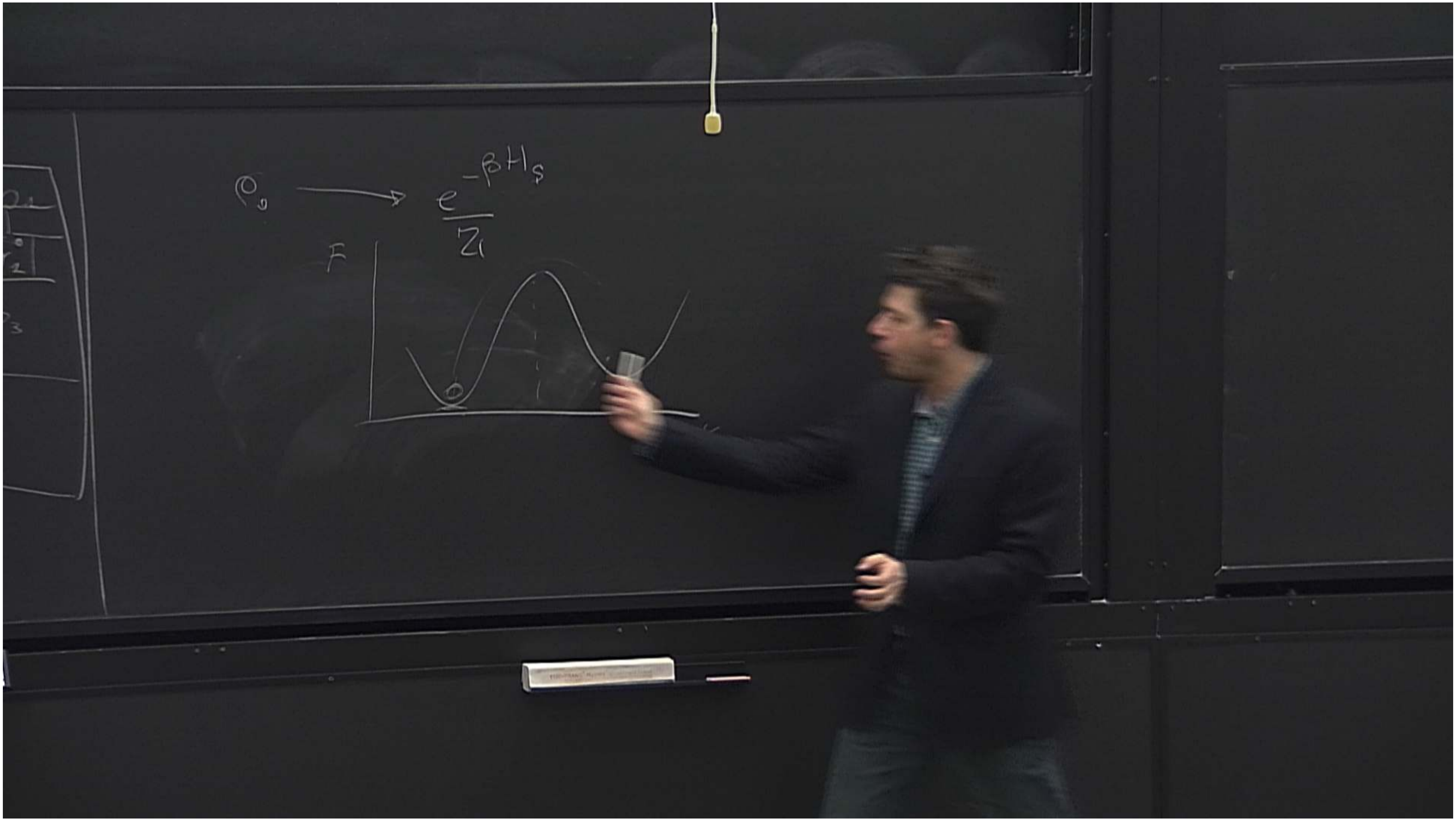


H(λ) = H_TC − λ Σ_i σ_i^x
− λ V
T.O. Phase
λ_c
λ << 1
- Degenerate GS
- GS locally indistinguishable
- emergent fermions
- decaying corr. functions
- long-range entanglement
A
Top. Entropy
λ >> 1 Boring
Paramagnet
[H(s), T_sym] = 0
TO_1
TO_2
TO_3
TO_4

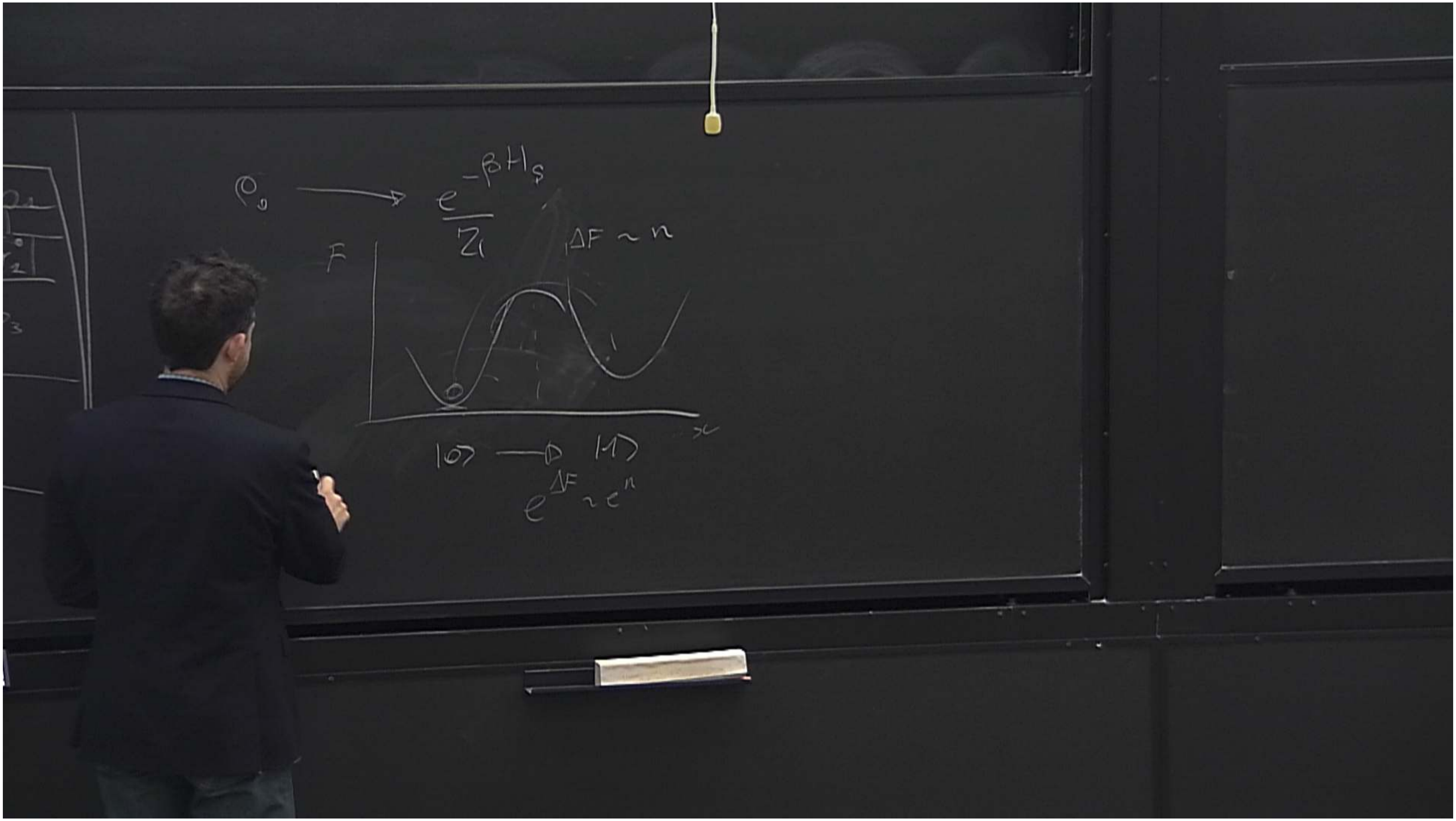


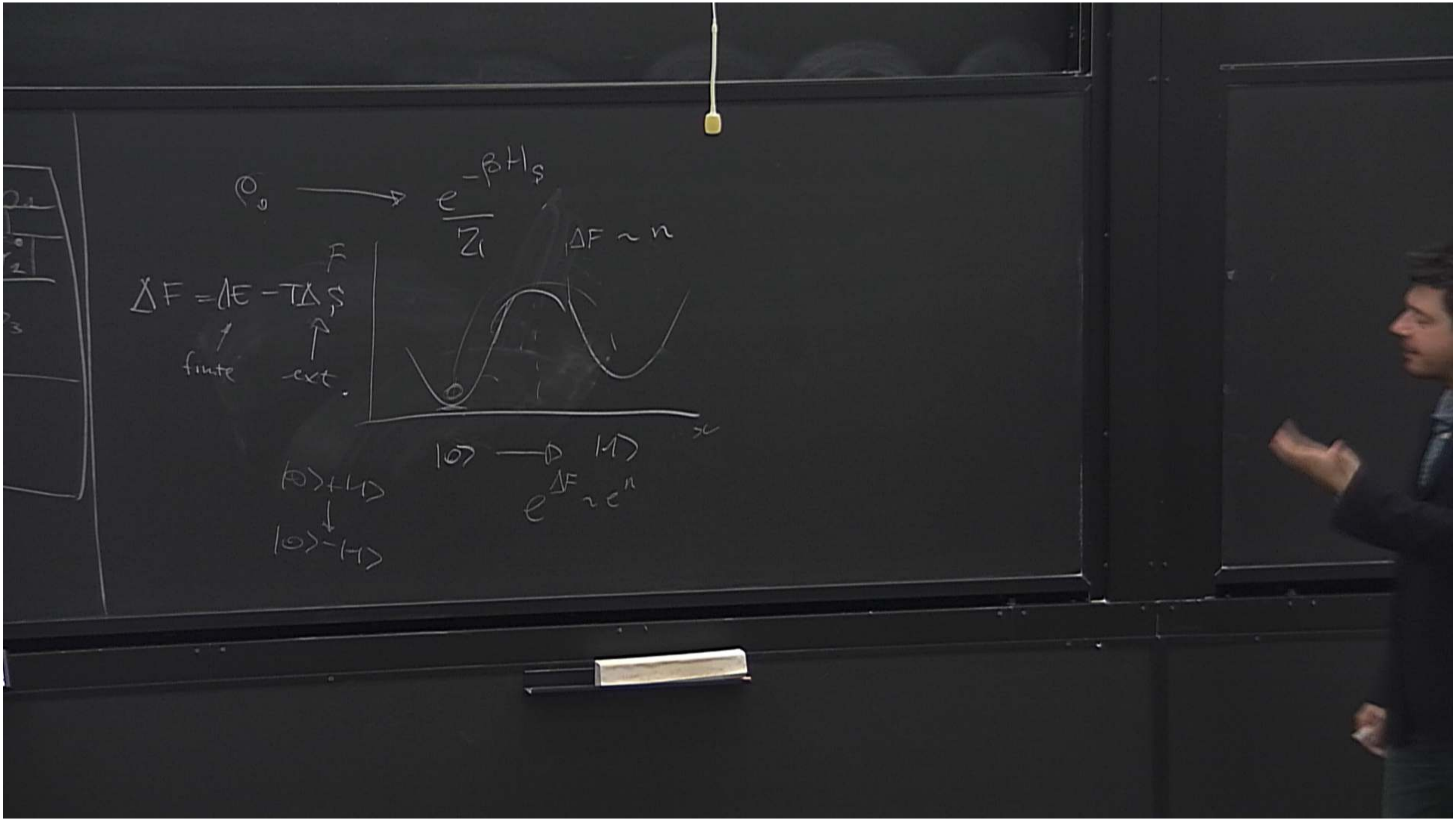
$\rho_s \rightarrow \frac{e^{-\beta H_s}}{Z_1}$

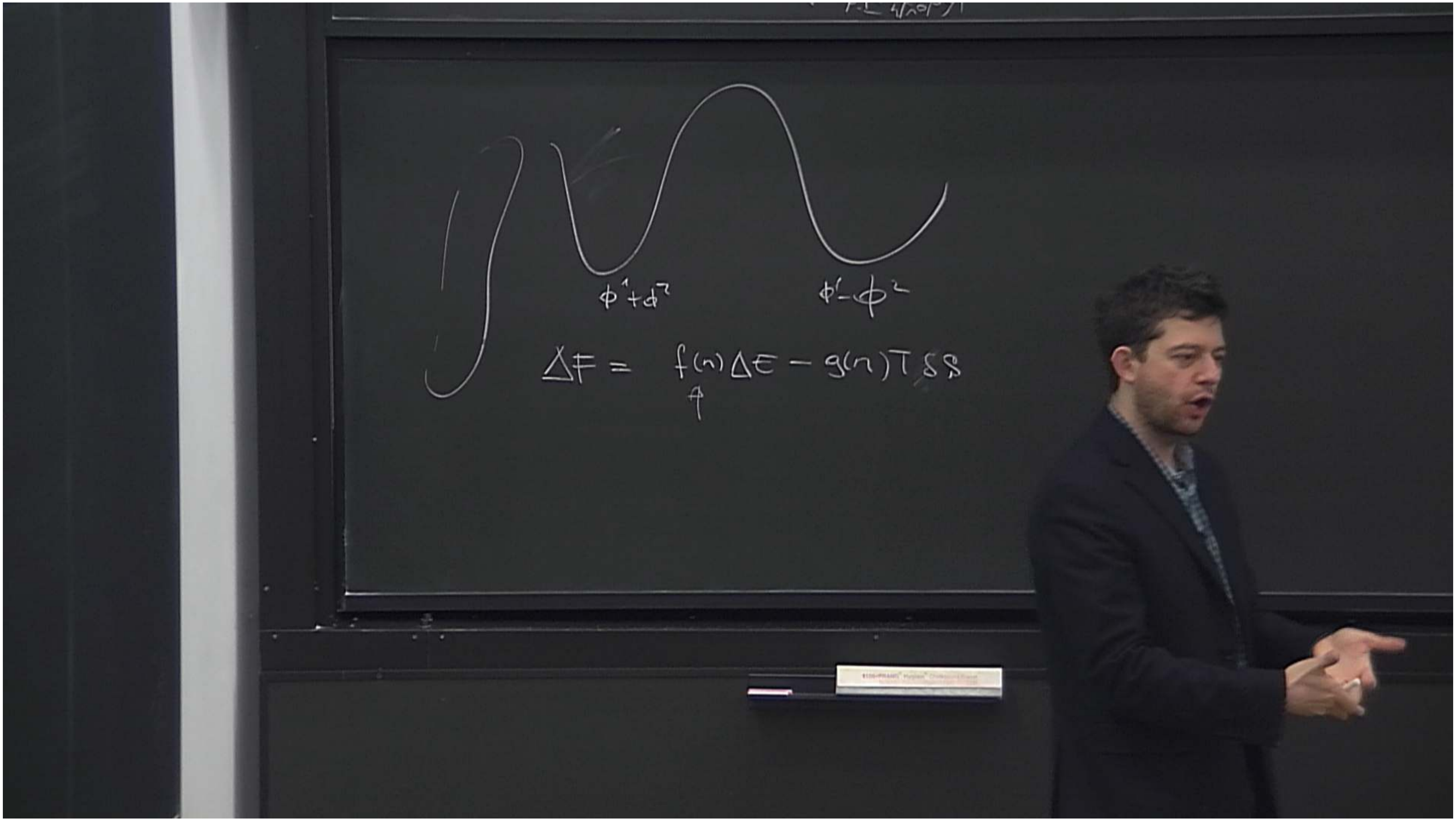


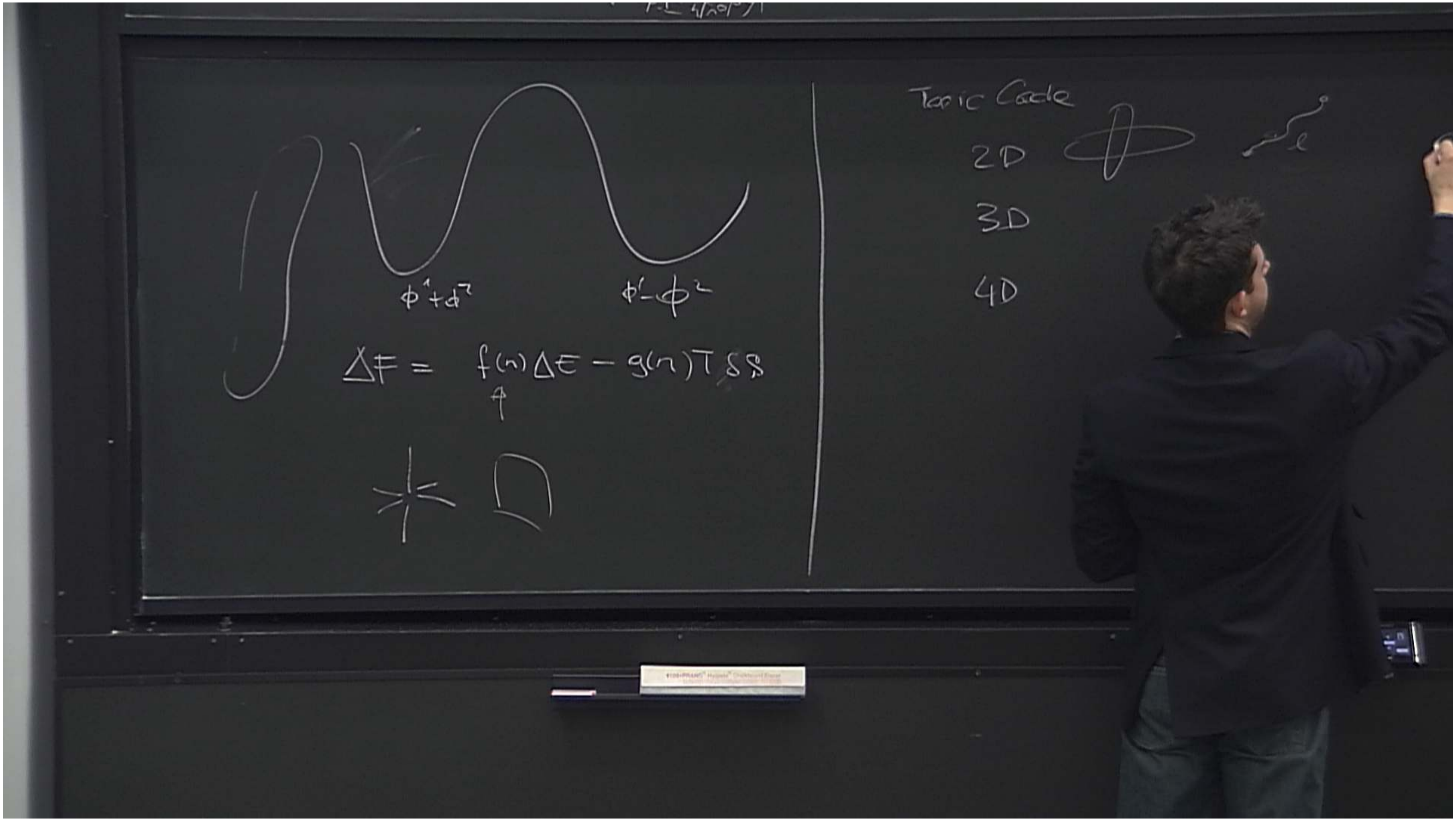


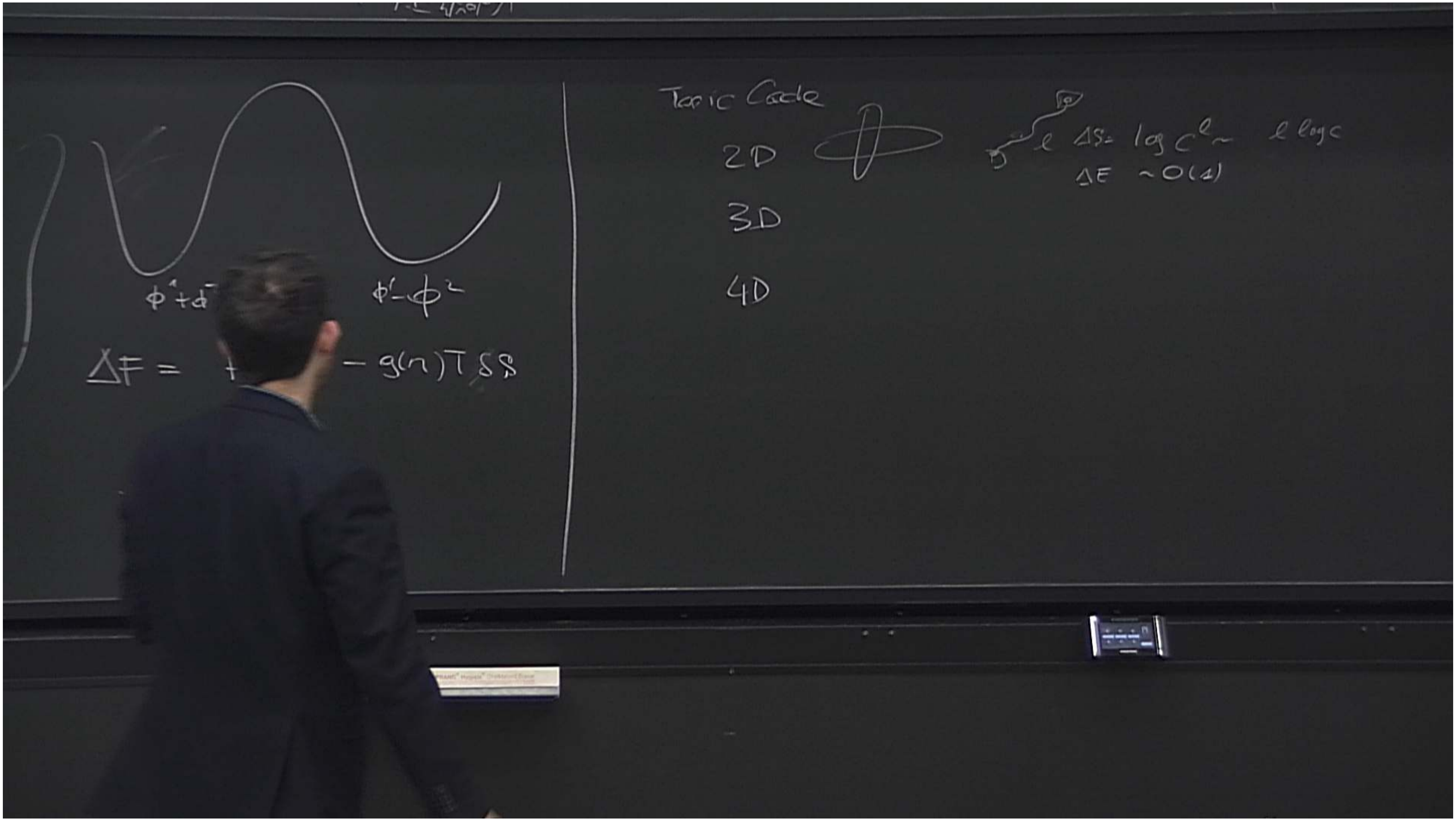
$\rho_0 \longrightarrow \frac{e^{-\beta H_s}}{Z_1}$
F

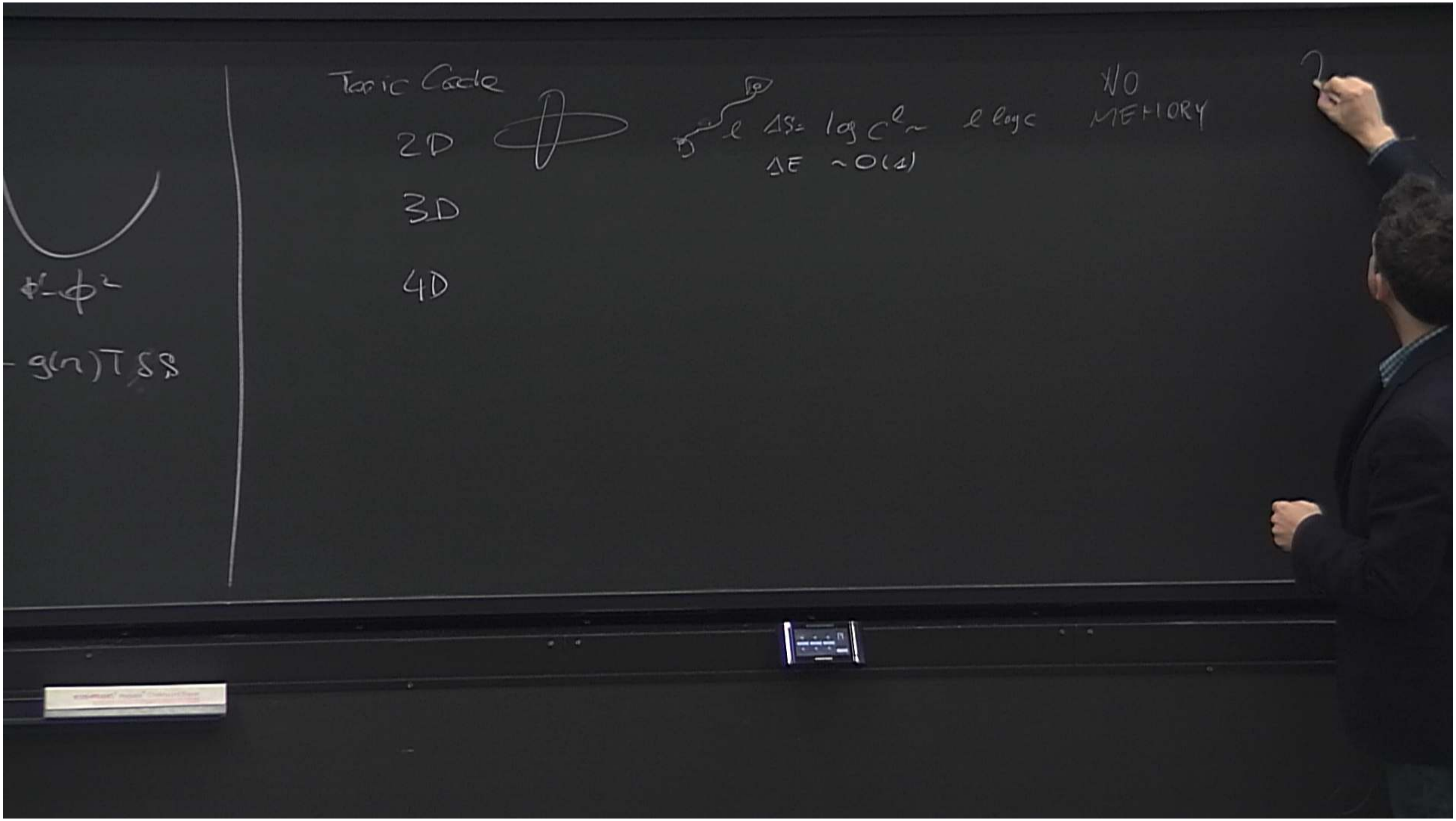

ρ₀ → e^{-βH_S} / Z₁
ΔF ~ n
F
x
|0⟩ → |1⟩
e^{ΔF} ~ e^n

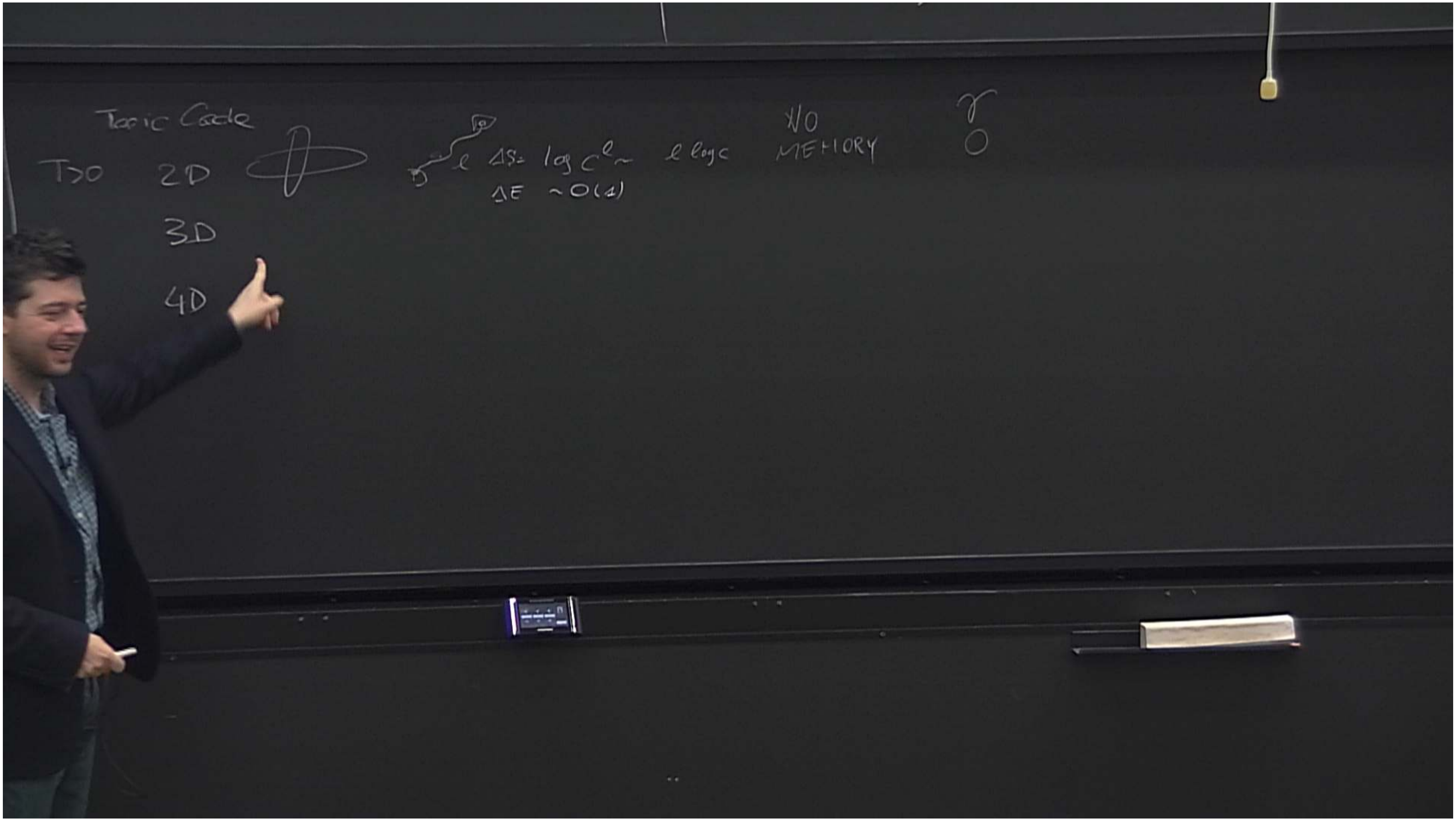

$\rho_0 \longrightarrow \frac{e^{-\beta H_S}}{Z_1}$
$\Delta F \sim n$
$\Delta F = \Delta E - T\Delta S$
finite
ext.
$|0\rangle \longrightarrow |1\rangle$
$e^{\Delta F} \sim e^{n}$
$|0\rangle + |1\rangle$
$|0\rangle - |1\rangle$

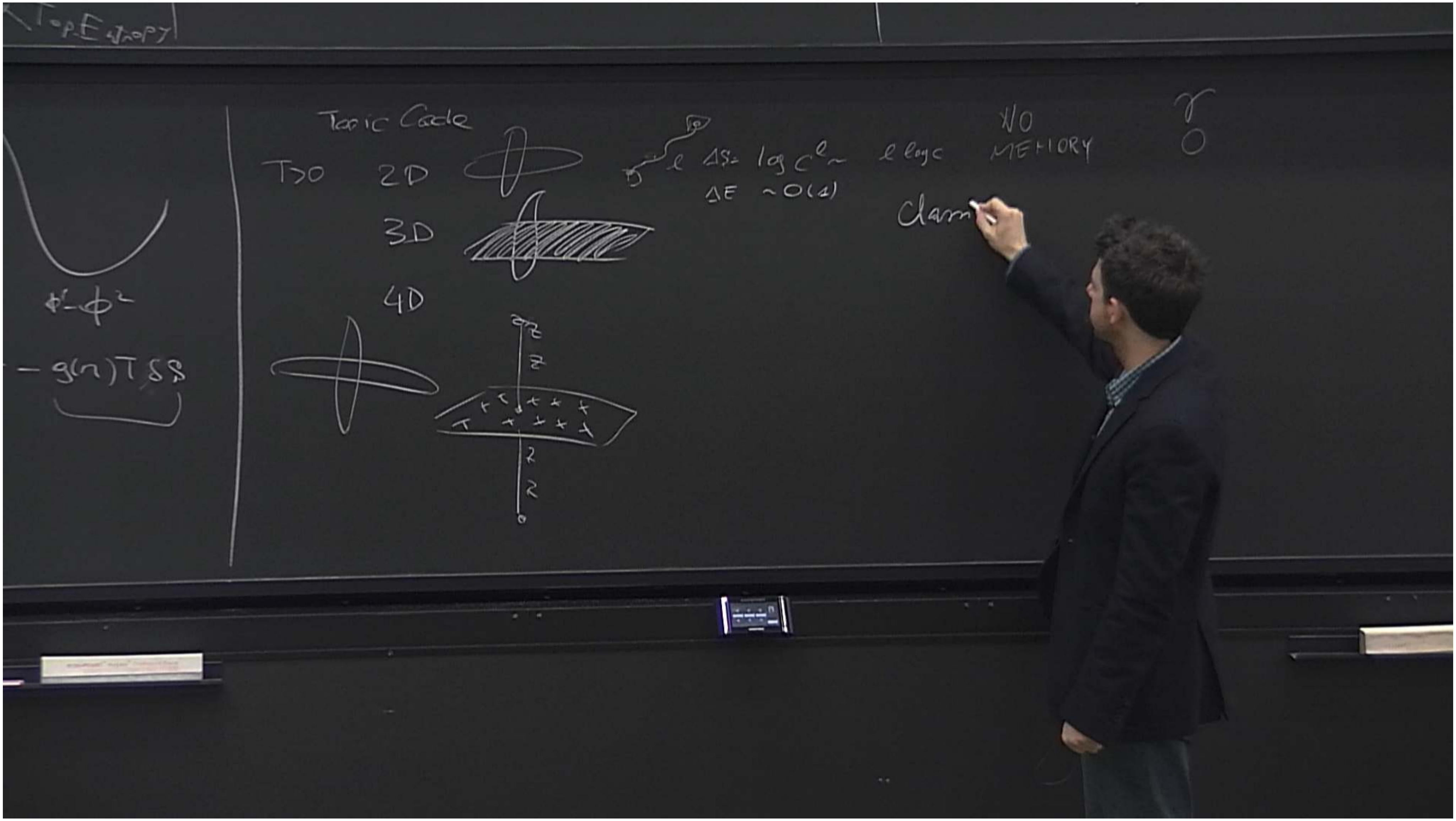

ΔF = f(n) ΔE − g(n) T δS

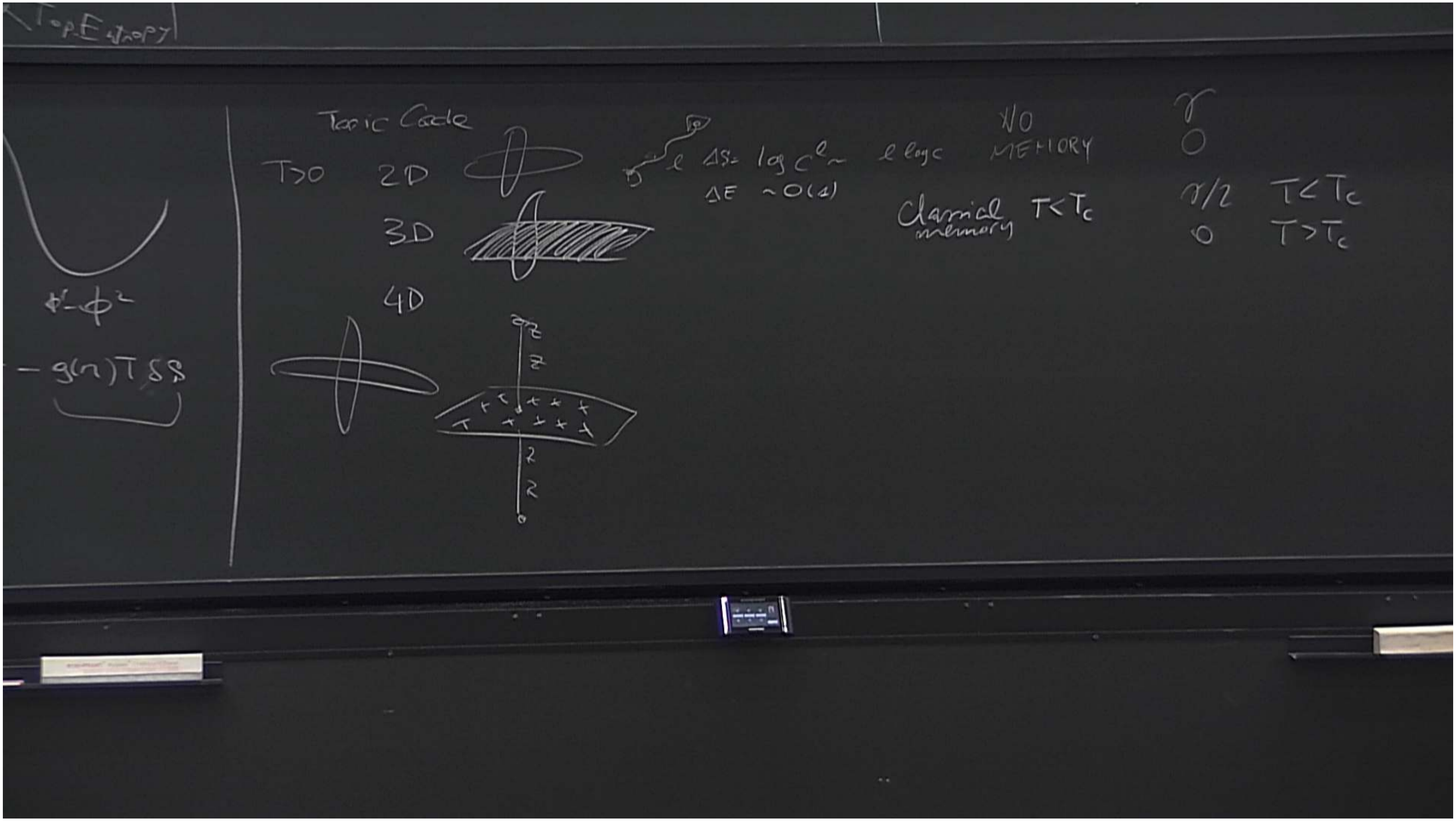

Toric Code
2D
3D
4D
ΔF = f(n)ΔE − g(n)TδS

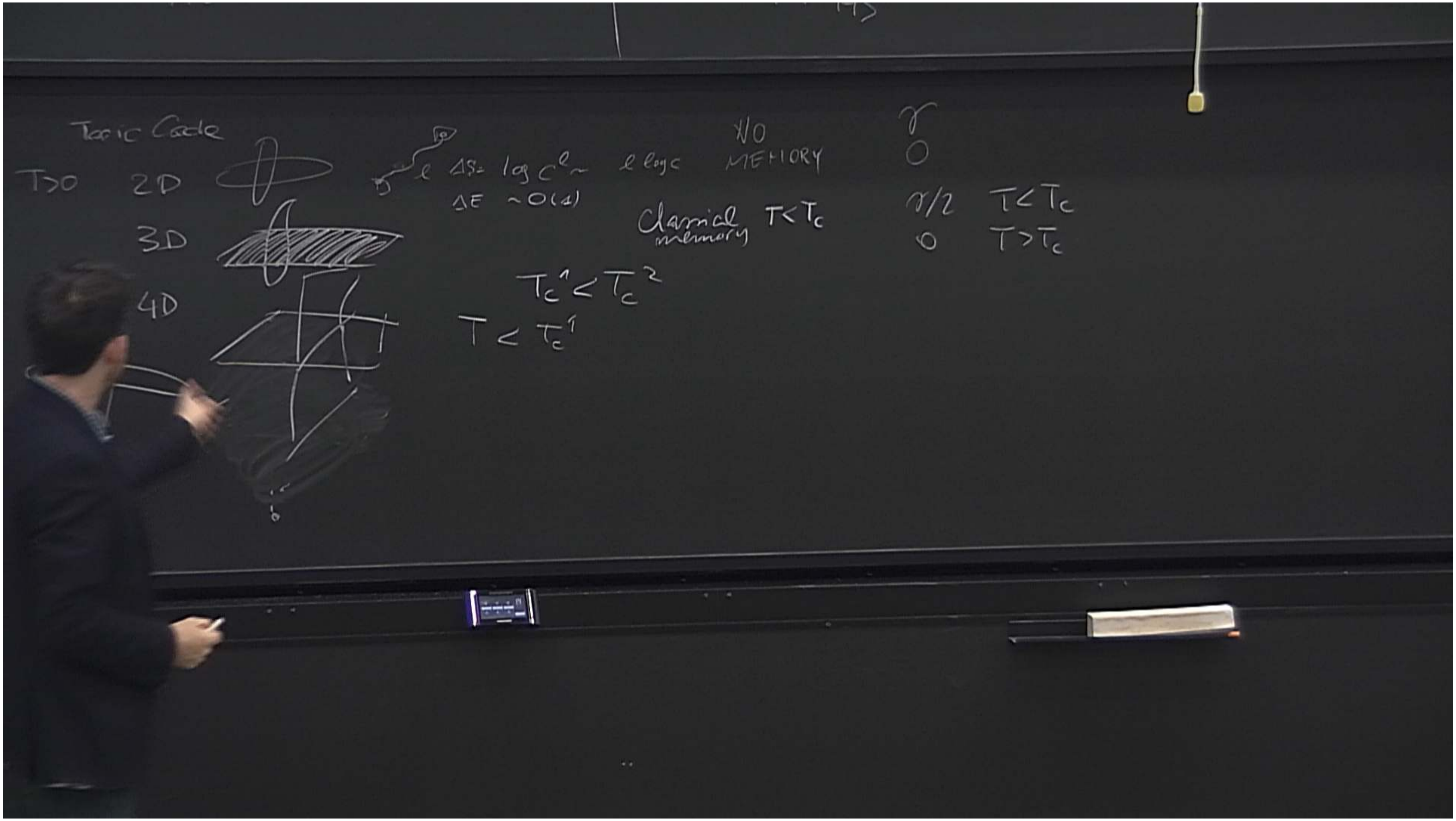

Toric Code
2D
3D
4D
ΔS = log c^l ~ l log c
ΔE ~ O(1)
ΔF =
− g(n) T δS

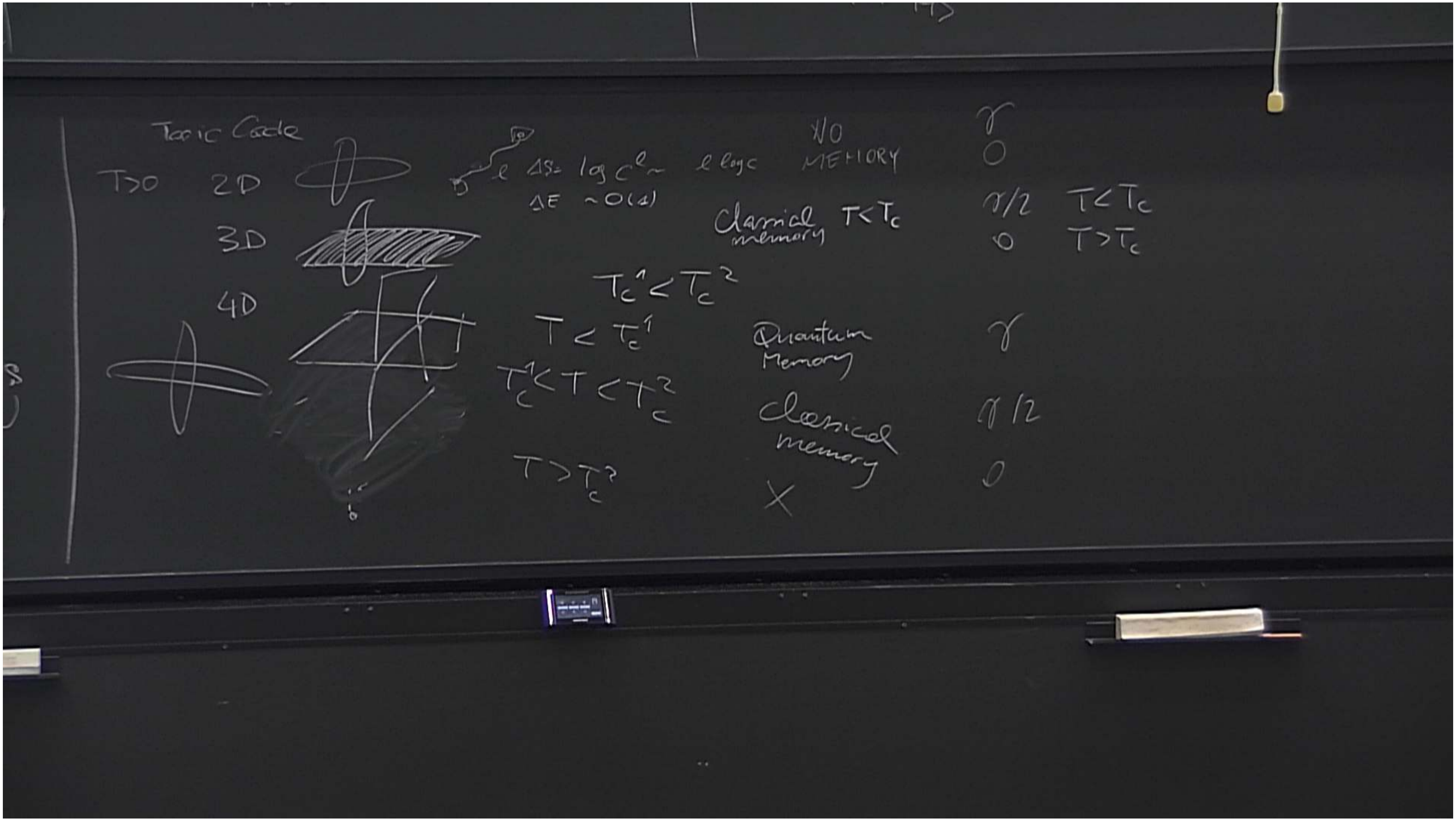

Toric Code
2D
3D
4D
ΔS = log c^ℓ ~ ℓ log c
ΔE ~ O(1)
NO MEMORY

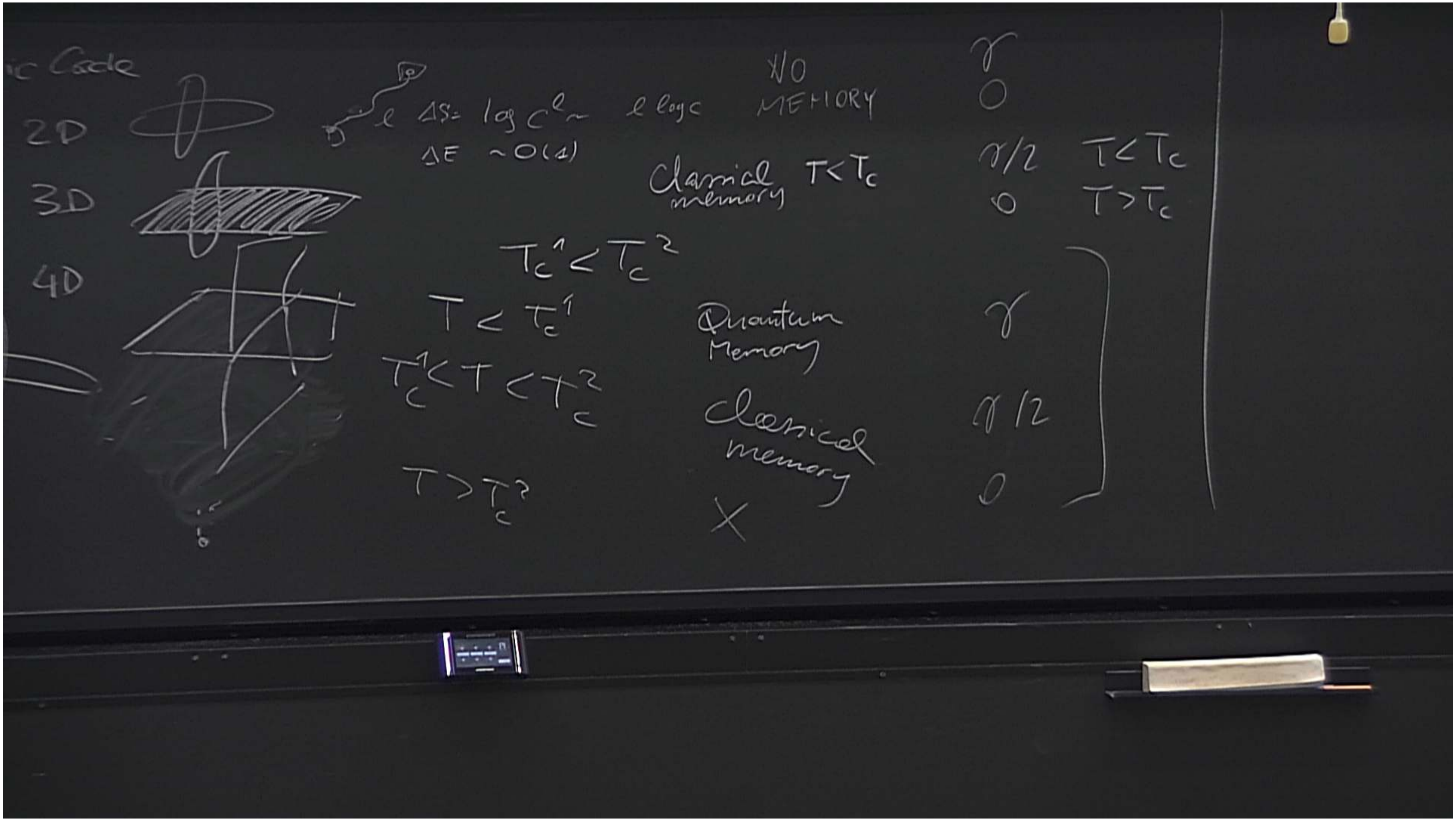

Toric Code
T>0
2D
3D
4D
ΔS= log c^ℓ ~ ℓ log c
ΔE ~ O(1)
N/O
MEMORY

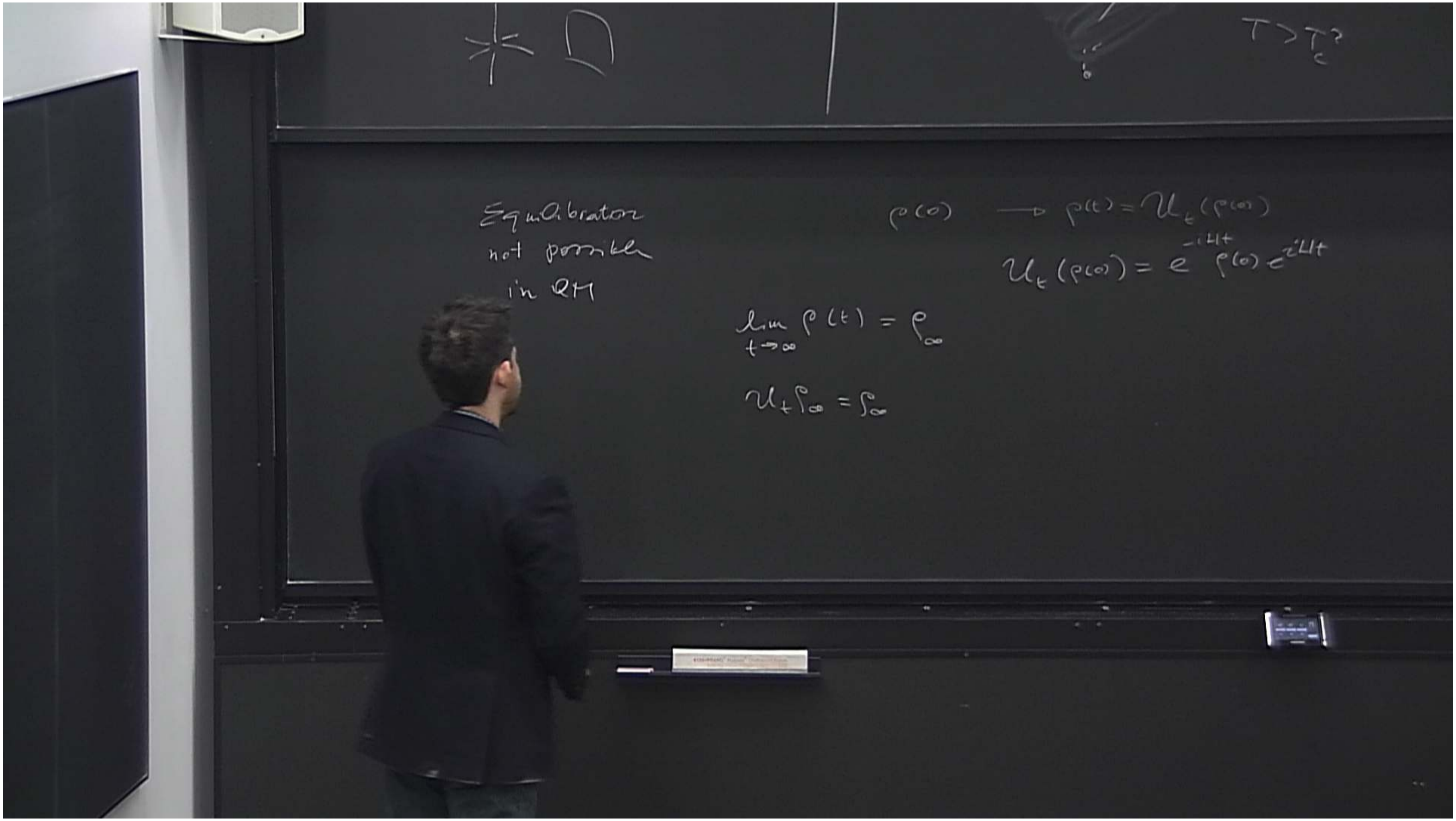

Toric Code
T>0
2D
3D
4D
NO MEMORY

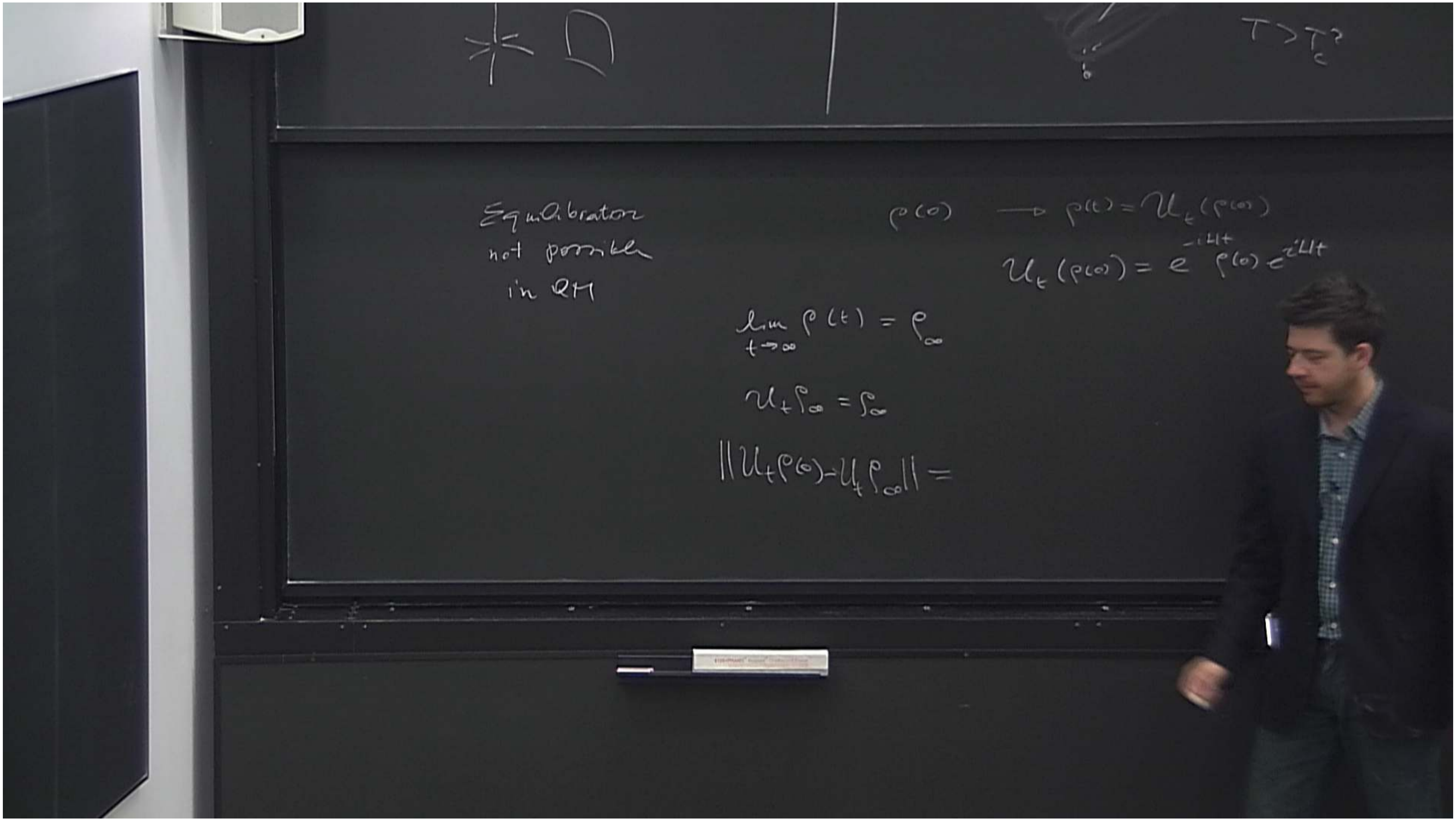

Toric Code
T>0
2D
3D
4D
ΔE ~O(1)
ℓ logc
MEMORY
Classical memory
T<Tc
γ/2
T<Tc
T>Tc
- g(r)TδS

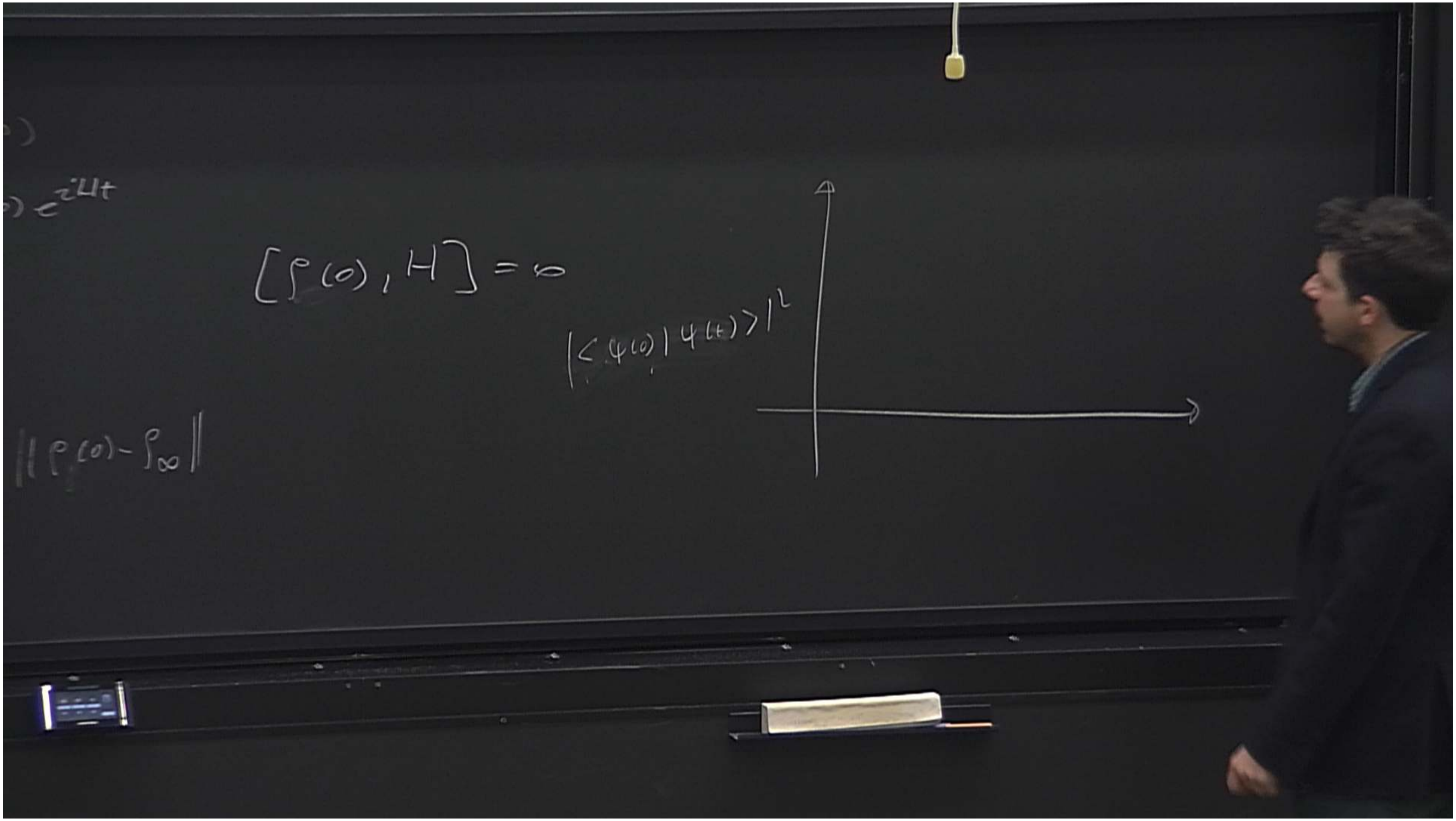

Toric Code
T>0
2D
3D
4D
NO
MEMORY
Classical memory
T<Tc
T<Tc
T>Tc

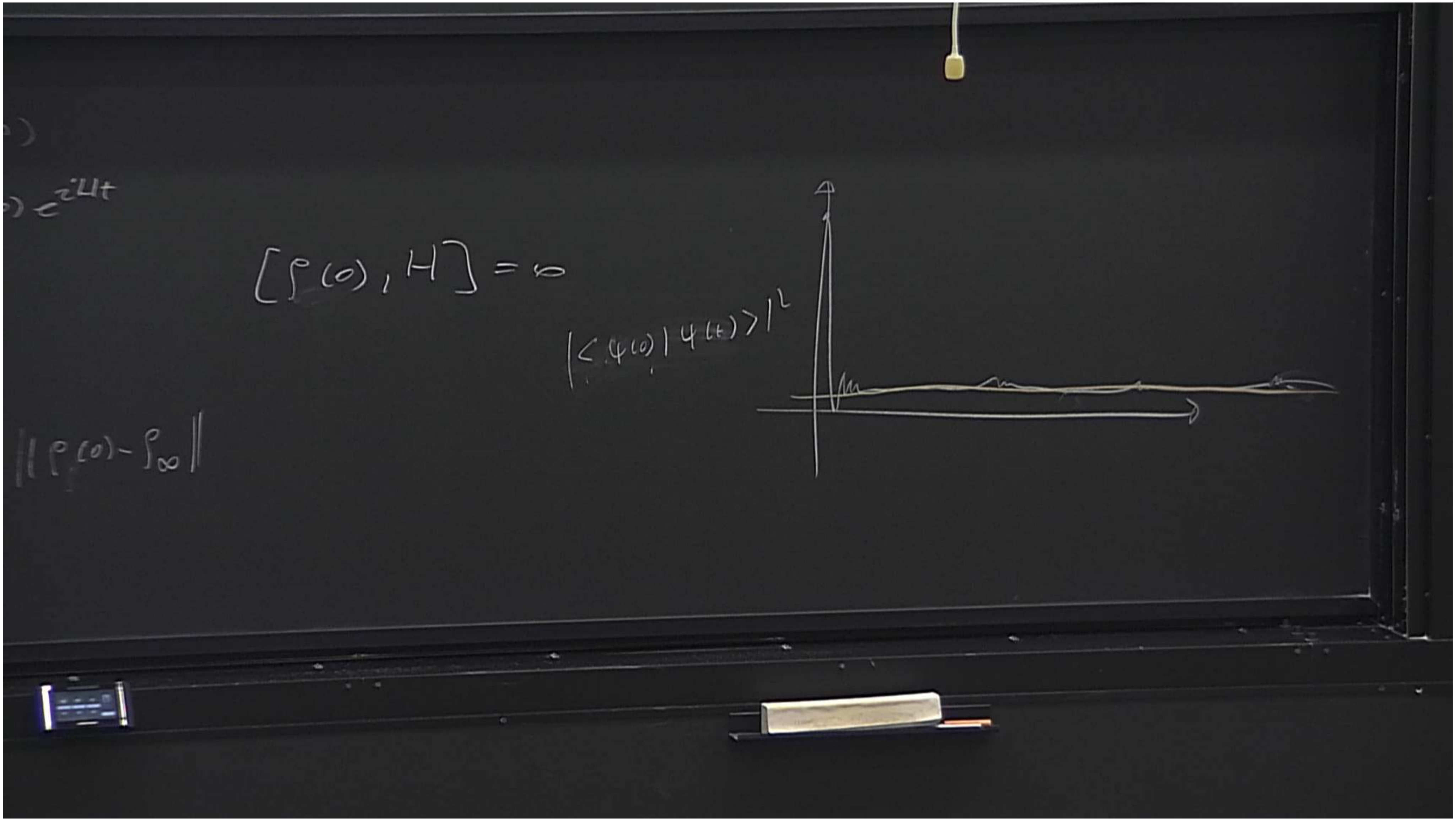

Toric Code
T>0
2D
3D
4D
ΔS= log c^l ~ l log c
ΔE ~ O(1)
NO MEMORY
Classical memory T<Tc
Tc^1 < Tc^2
T < Tc^1
Quantum Memory
Tc^1 < T < Tc^2
classical memory
T > Tc^2
X
γ
0
γ/2 T<Tc
0 T>Tc
γ
γ/2
0


2D
3D
4D
ΔS = log c^l ~ l log c
ΔE ~ O(1)
NO MEMORY
Classical memory T<Tc
T<Tc
T>Tc
Tc1 < Tc2
T < Tc1
Tc1 < T < Tc2
T > Tc2
Quantum Memory
classical memory
γ/2


T > T_c?
Equilibration
not possible
in QM
ρ(0) → ρ(t) = U_t(ρ(0))
U_t(ρ(0)) = e^{-iHt} ρ(0) e^{iHt}
lim_{t→∞} ρ(t) = ρ_∞
U_t ρ_∞ = ρ_∞


$T > T_c$?
Equilibraton
not possible
in QM
$\rho(0) \longrightarrow \rho(t) = \mathcal{U}_t(\rho(0))$
$\mathcal{U}_t(\rho(0)) = e^{-iHt}\rho(0)e^{iHt}$
$\lim_{t\to\infty} \rho(t) = \rho_\infty$
$\mathcal{U}_t \rho_\infty = \rho_\infty$
$\|\mathcal{U}_t\rho(0) - \mathcal{U}_t\rho_\infty\| =$


e^{-iHt}
[ρ(0), H] = 0
|<ψ(0)|ψ(t)>|²
||ρ(0) - ρ∞||


[ρ(0), H] = 0
|<ψ(0)|ψ(t)>|²
||ρ(0) - ρ∞||