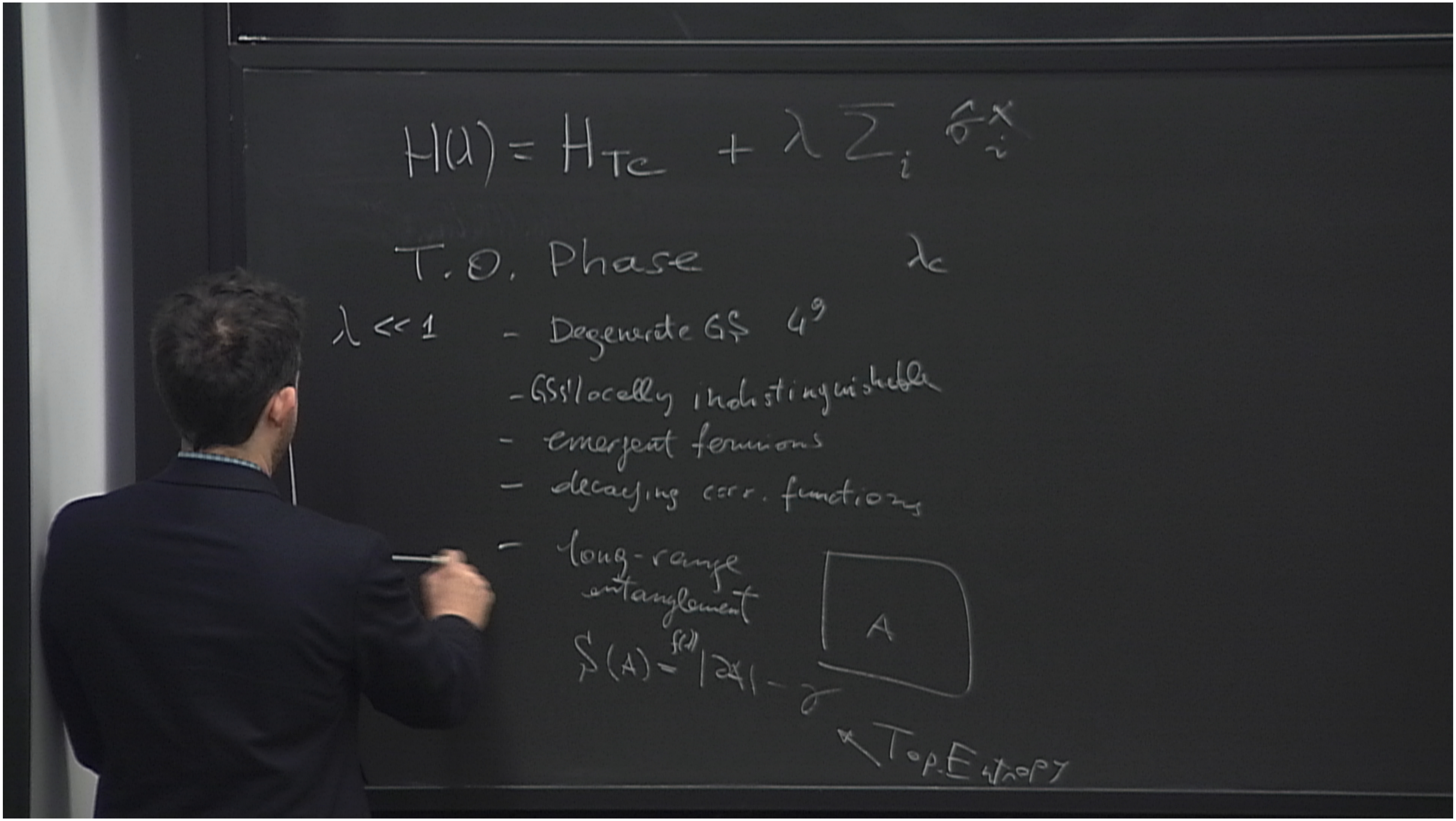
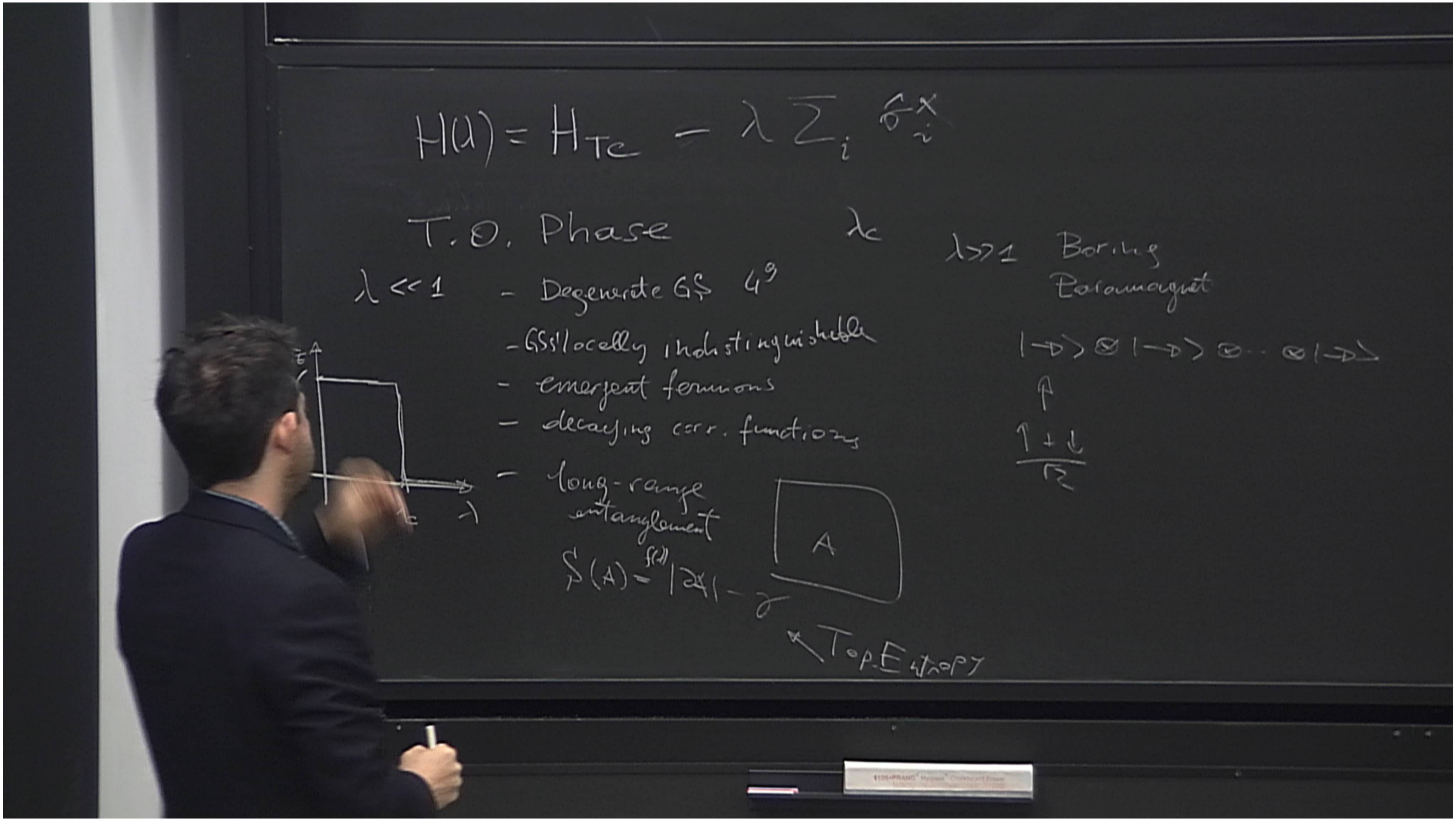
Title: 13/14 PSI - Condensed Matter Review - Lecture 14

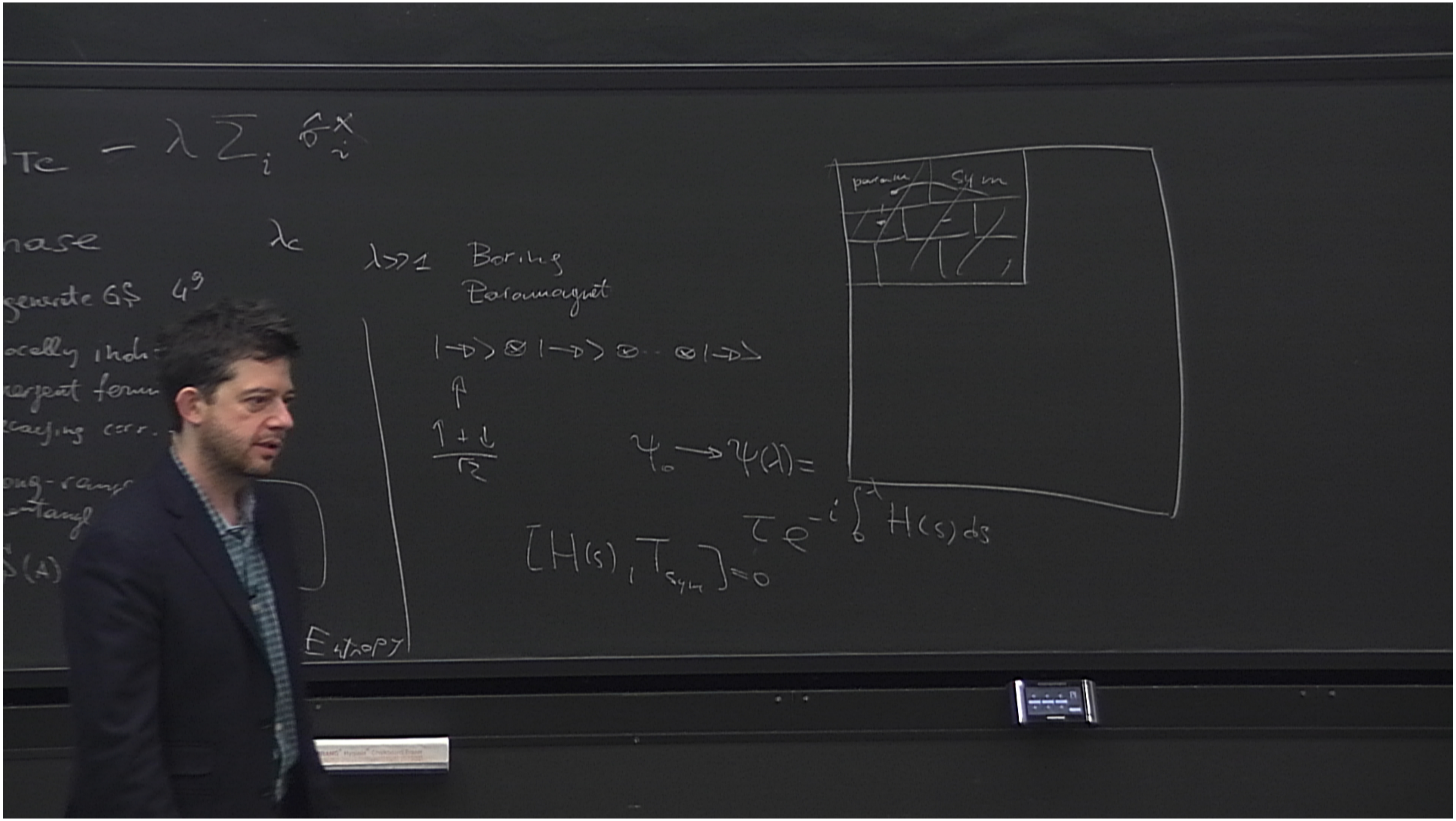
Date: Feb 14, 2014 09:00 AM

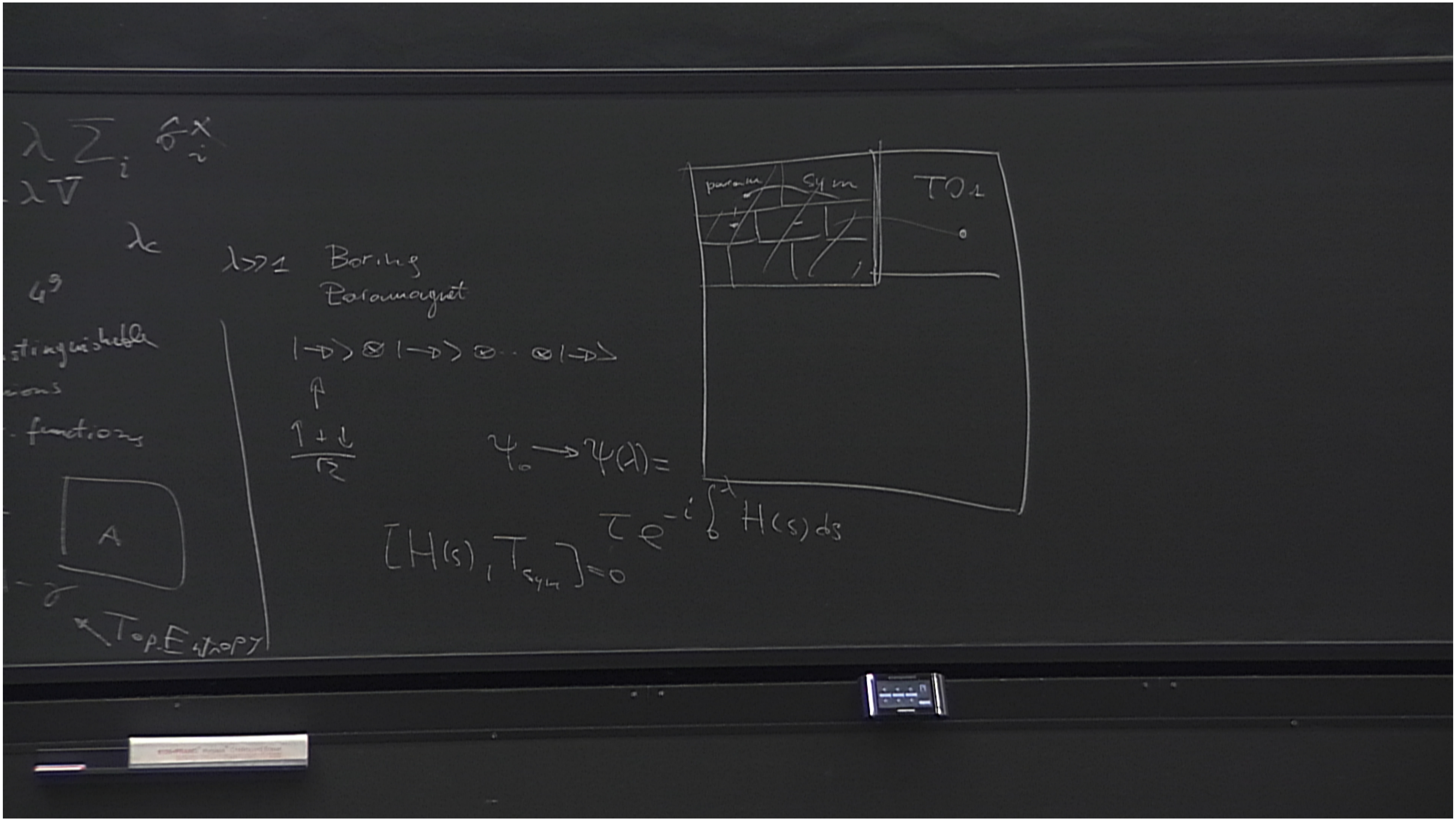
URL: http://pirsa.org/14020107

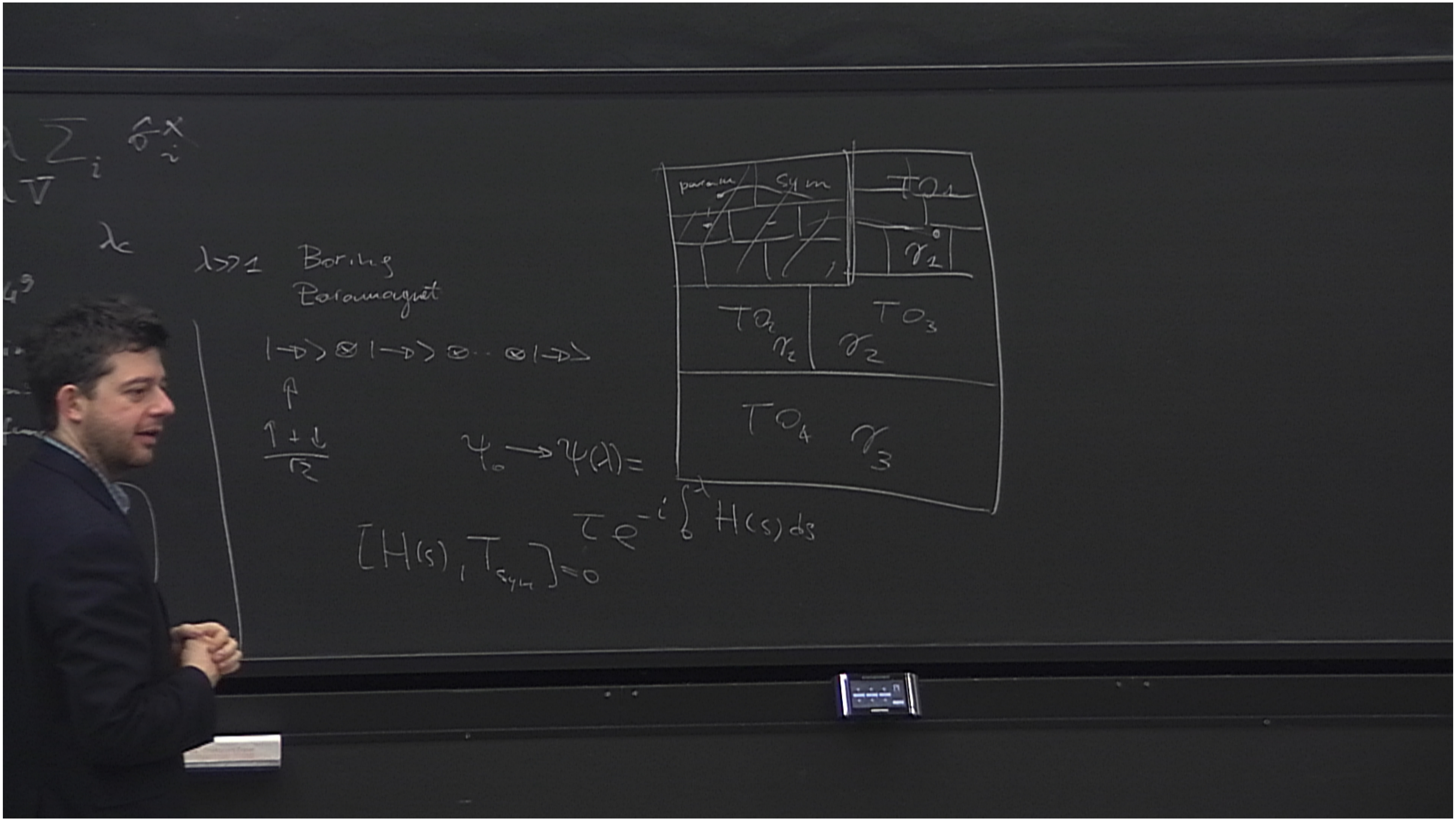
Abstract:

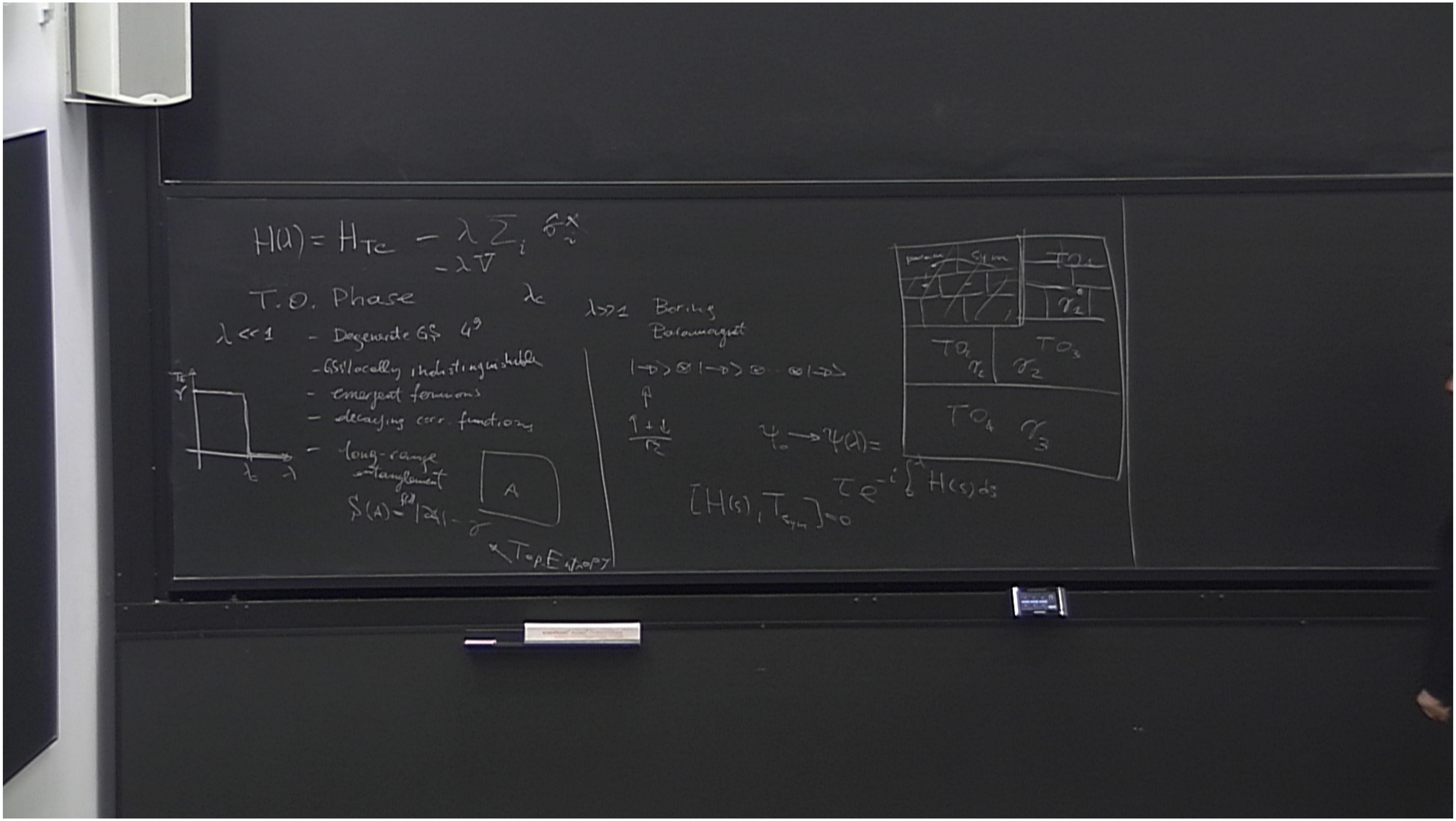

$H(\lambda) = H_{TC} + \lambda \sum_i \sigma_i^x$
T.O. Phase
λ_c
$\lambda << 1$
- Degenerate GS 4^g
- GS's locally indistinguishable
- emergent fermions
- decaying corr. functions
- long-range entanglement
$S(A) = f(d)|\partial A| - \gamma$
A
Top. Entropy

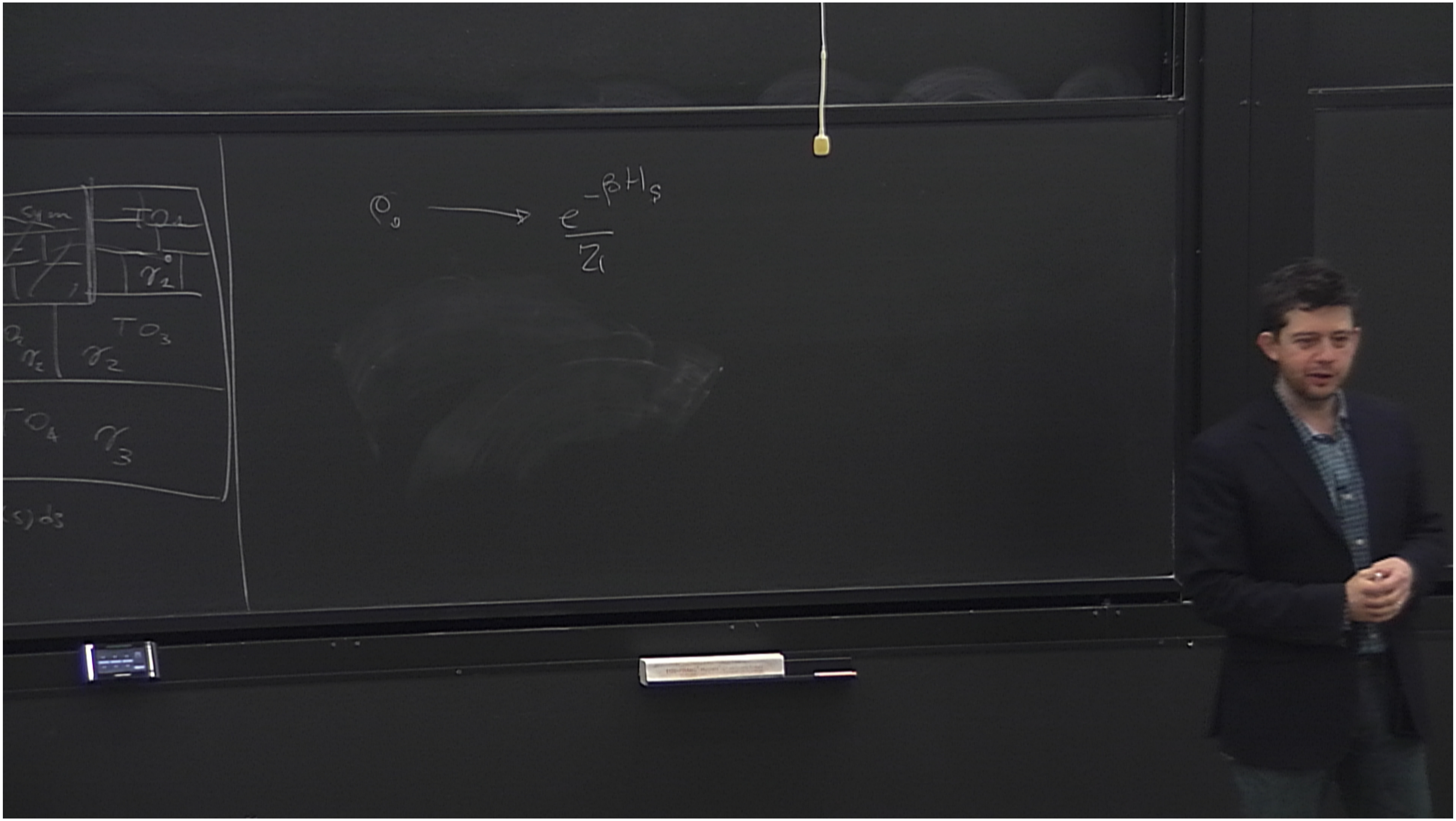

H(λ) = H_TC − λ Σ_i σ_i^x
T.O. Phase
λc
λ >> 1 Boring
Paramagnet
λ << 1
- Degenerate GS 4^g
- GS's locally indistinguishable
- emergent fermions
- decaying corr. functions
- long-range entanglement
S(A) = |∂A| − γ
A
Top. Entropy
|→> ⊗ |→> ⊗ ... ⊗ |→>
↑ + ↓
√2

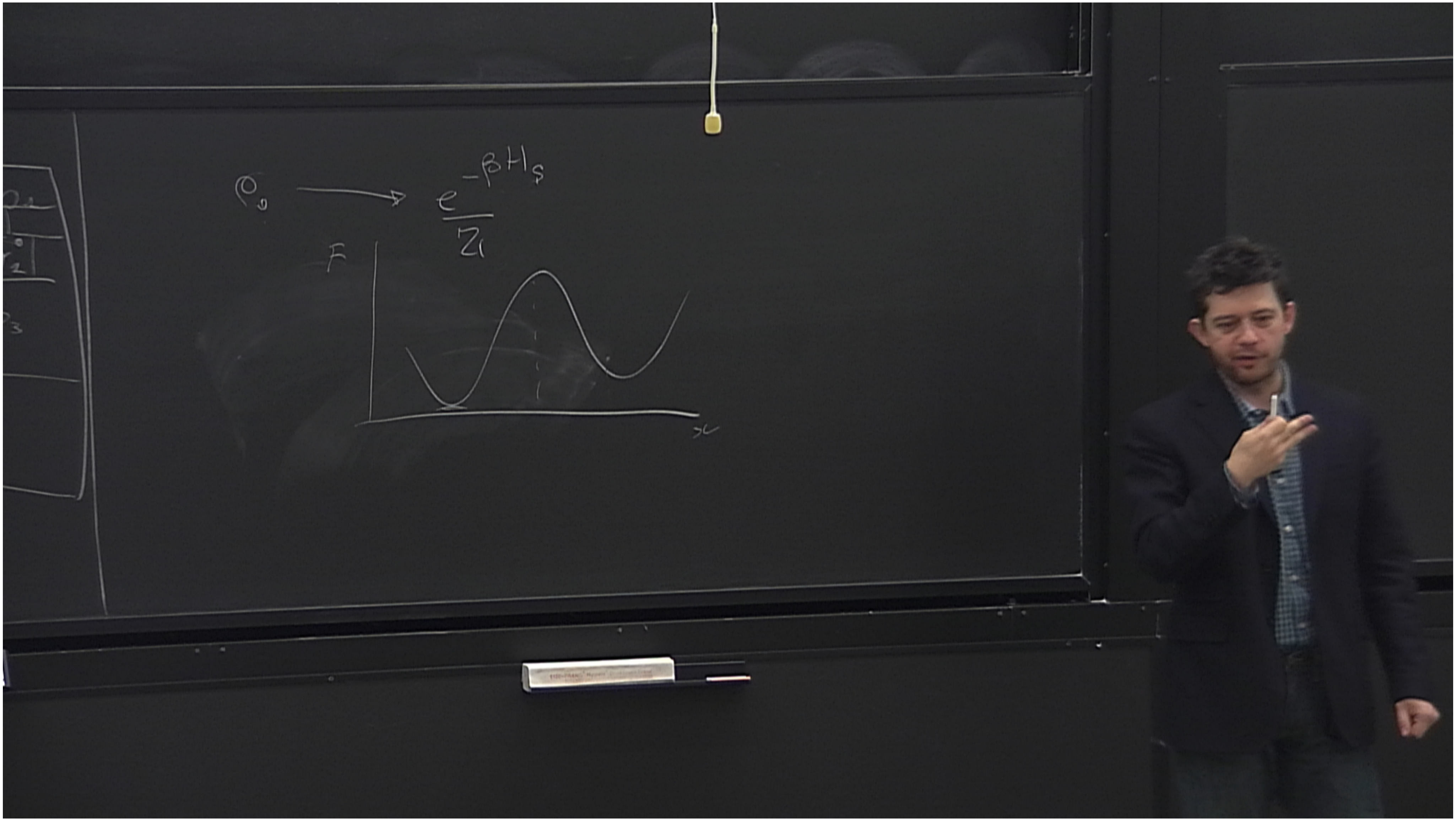

λ>>1 Boring
Paramagnet
Entropy
sym

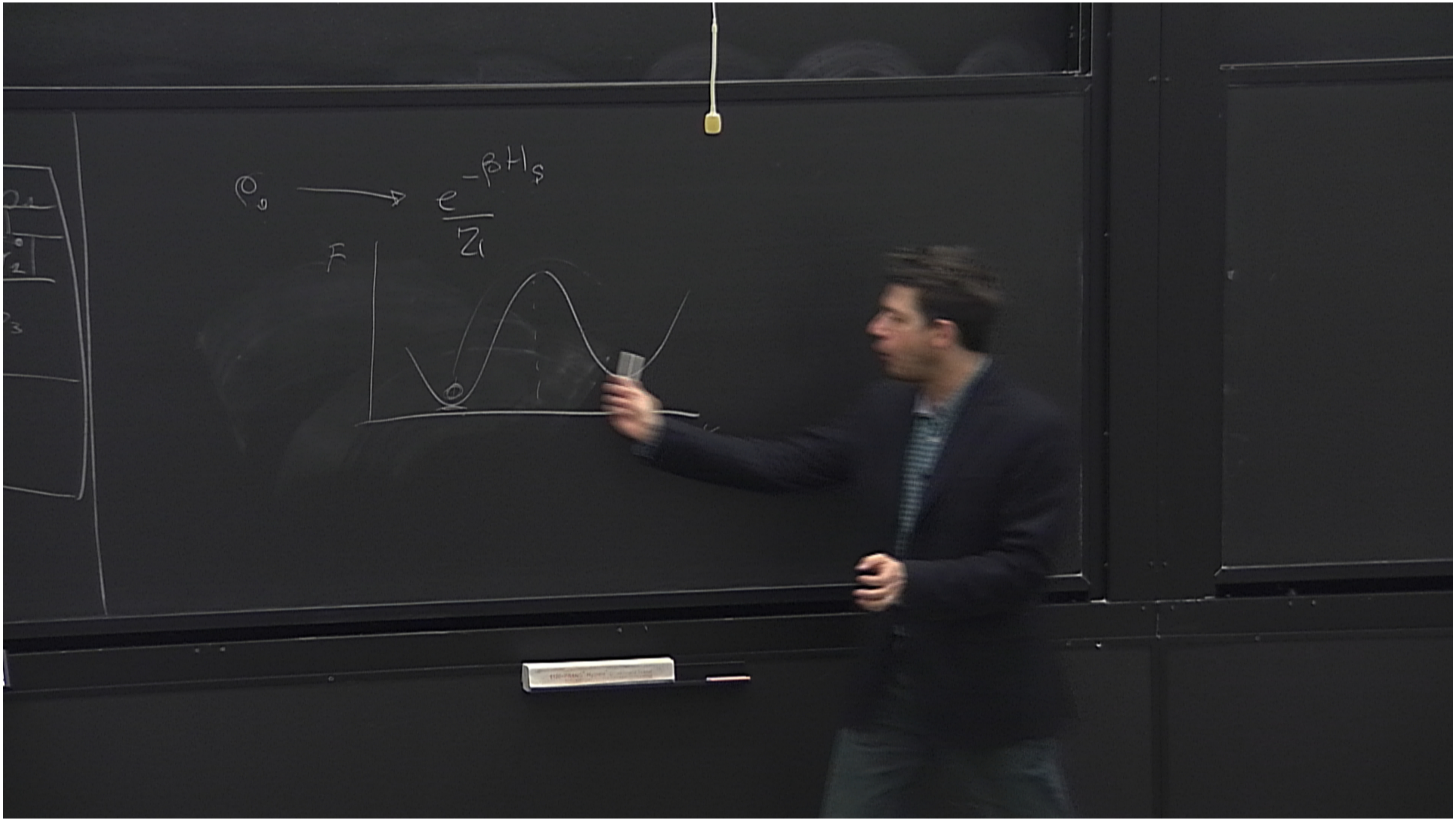

λ>>1 Boring
Paramagnet
TO1
A
Top. Entropy
[H(s), T_sym] = 0


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


H(λ) = H_TC − λ Σ_i σ^x
− λV
T.O. Phase
λc
λ << 1
- Degenerate GS 4^g
- GS's 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

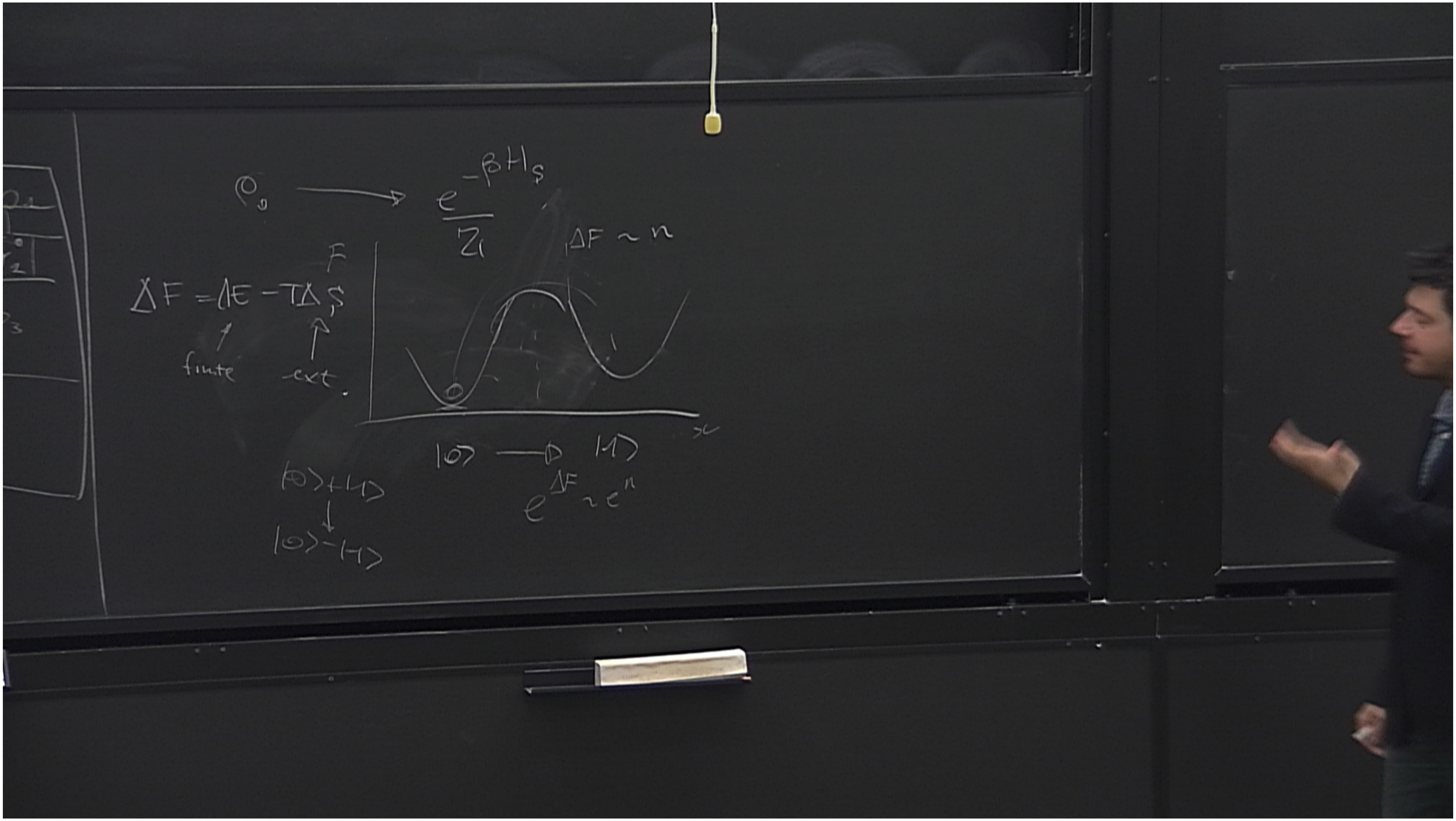

ρs → e^−βHs / Z1
TO3
TO4


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

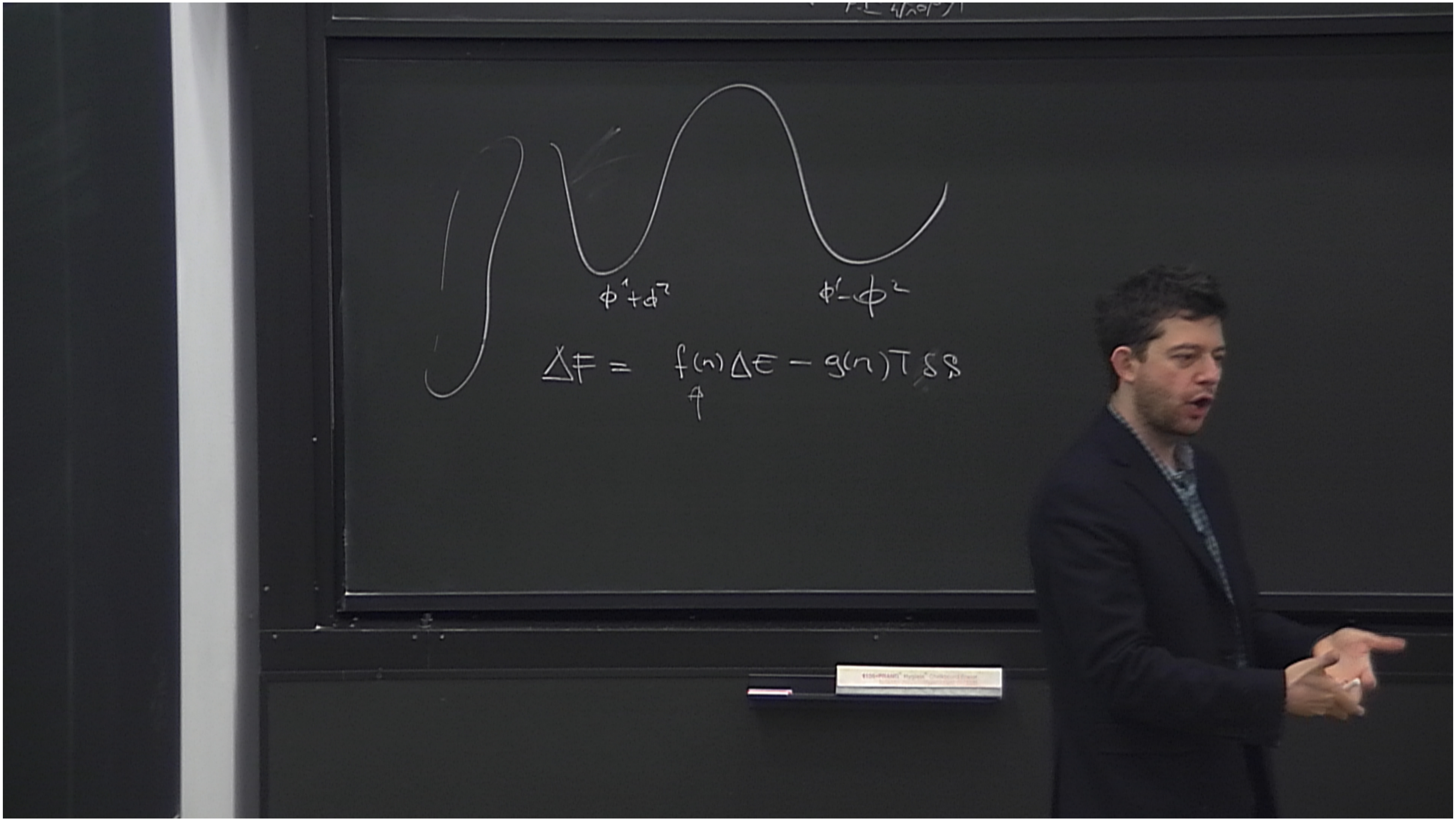


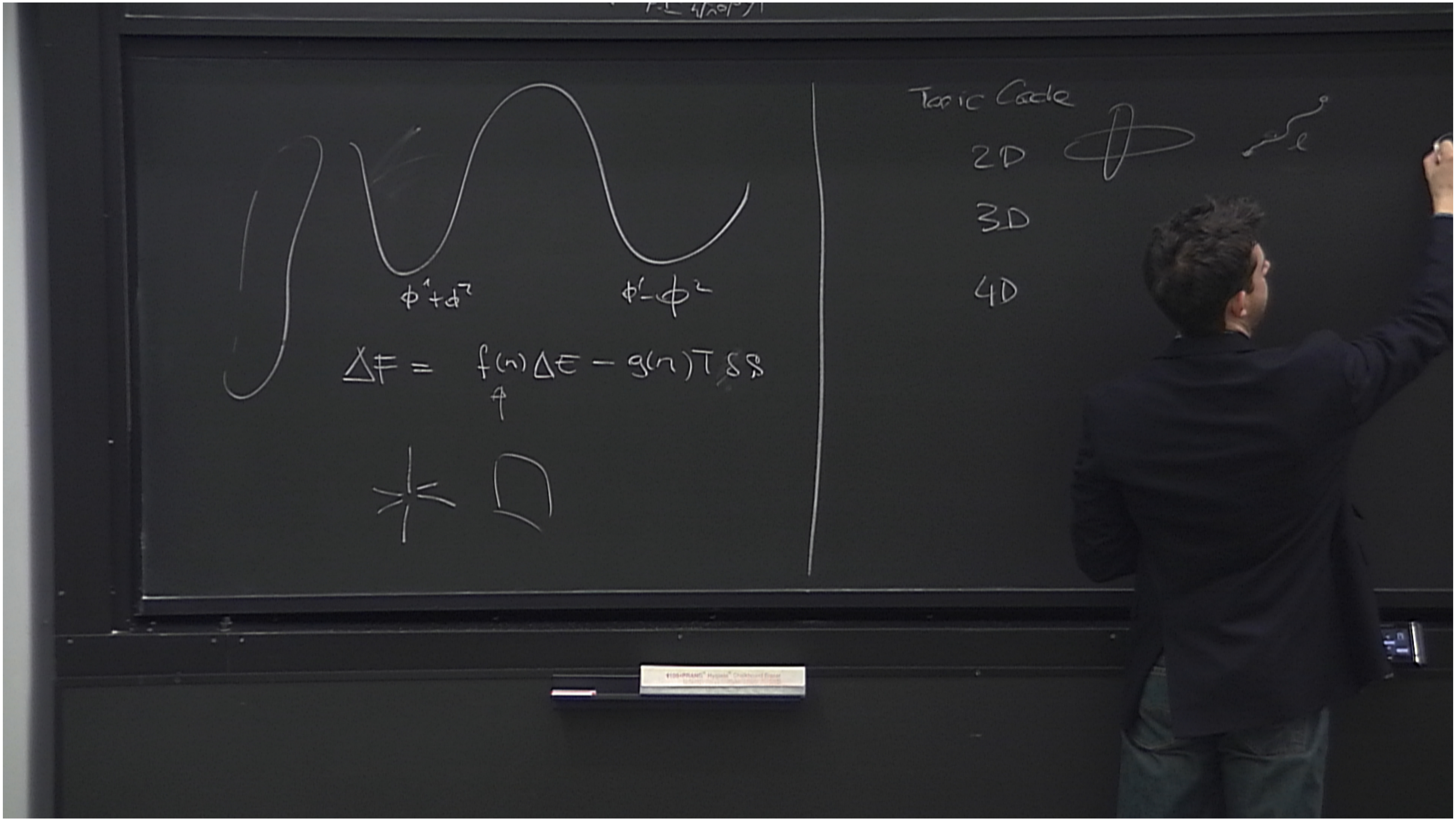
$\rho_0 \longrightarrow \frac{e^{-\beta H_s}}{Z_1}$
F

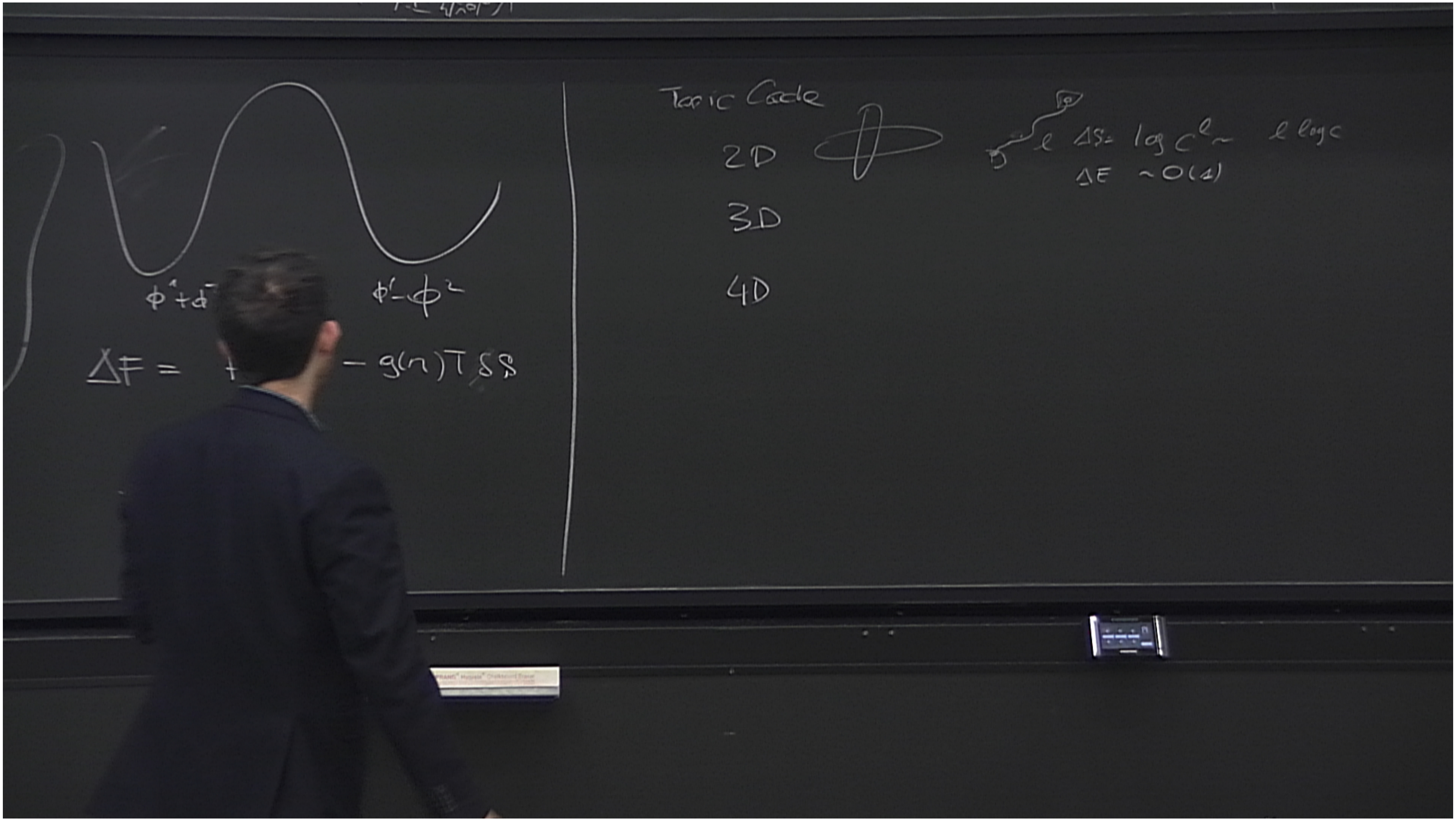

ρ₀ → e^{-βH_s} / Z₁
ΔF ~ n
F
x
|0⟩ → |1⟩
e^{ΔF} ~ e^n

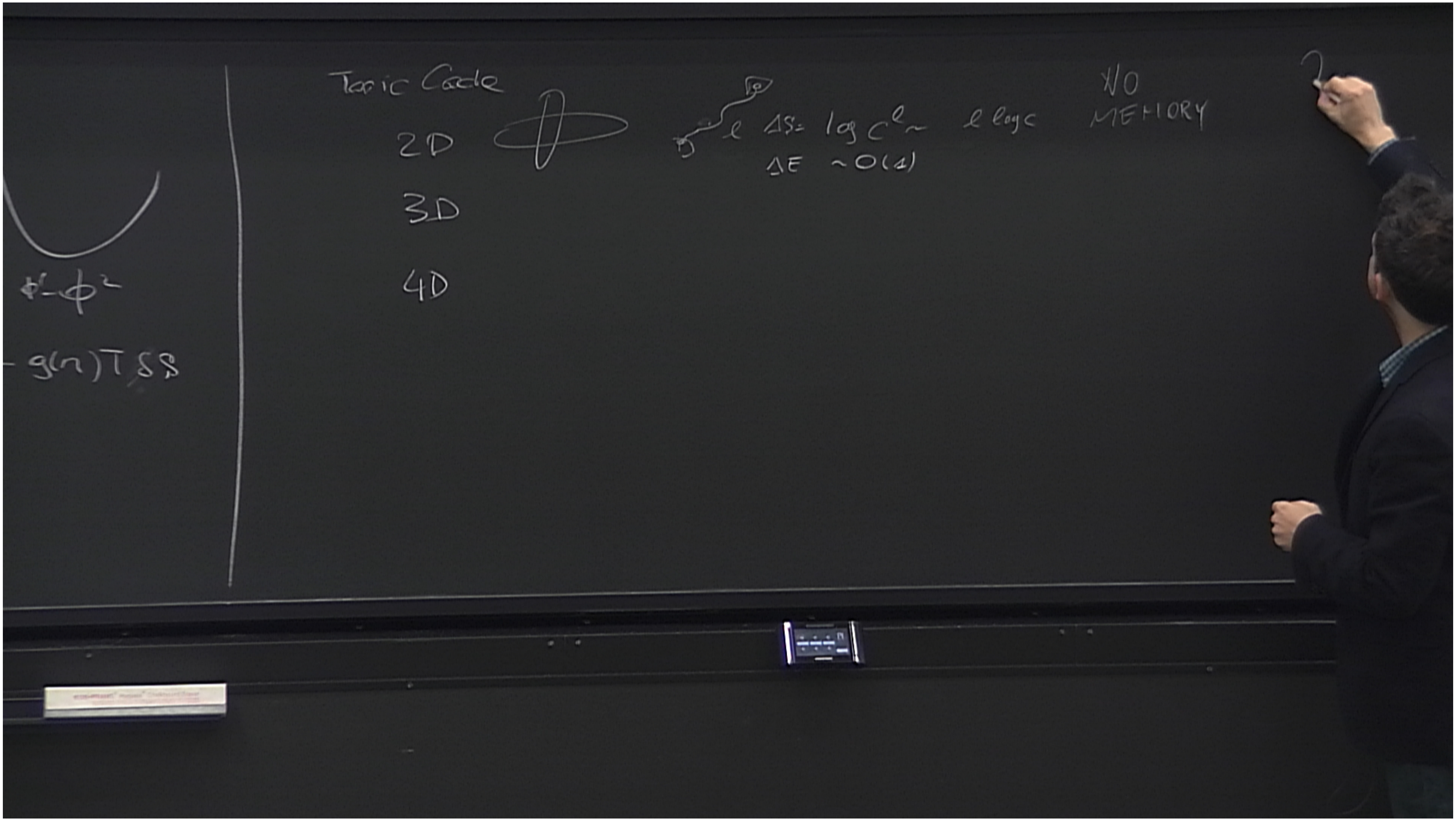


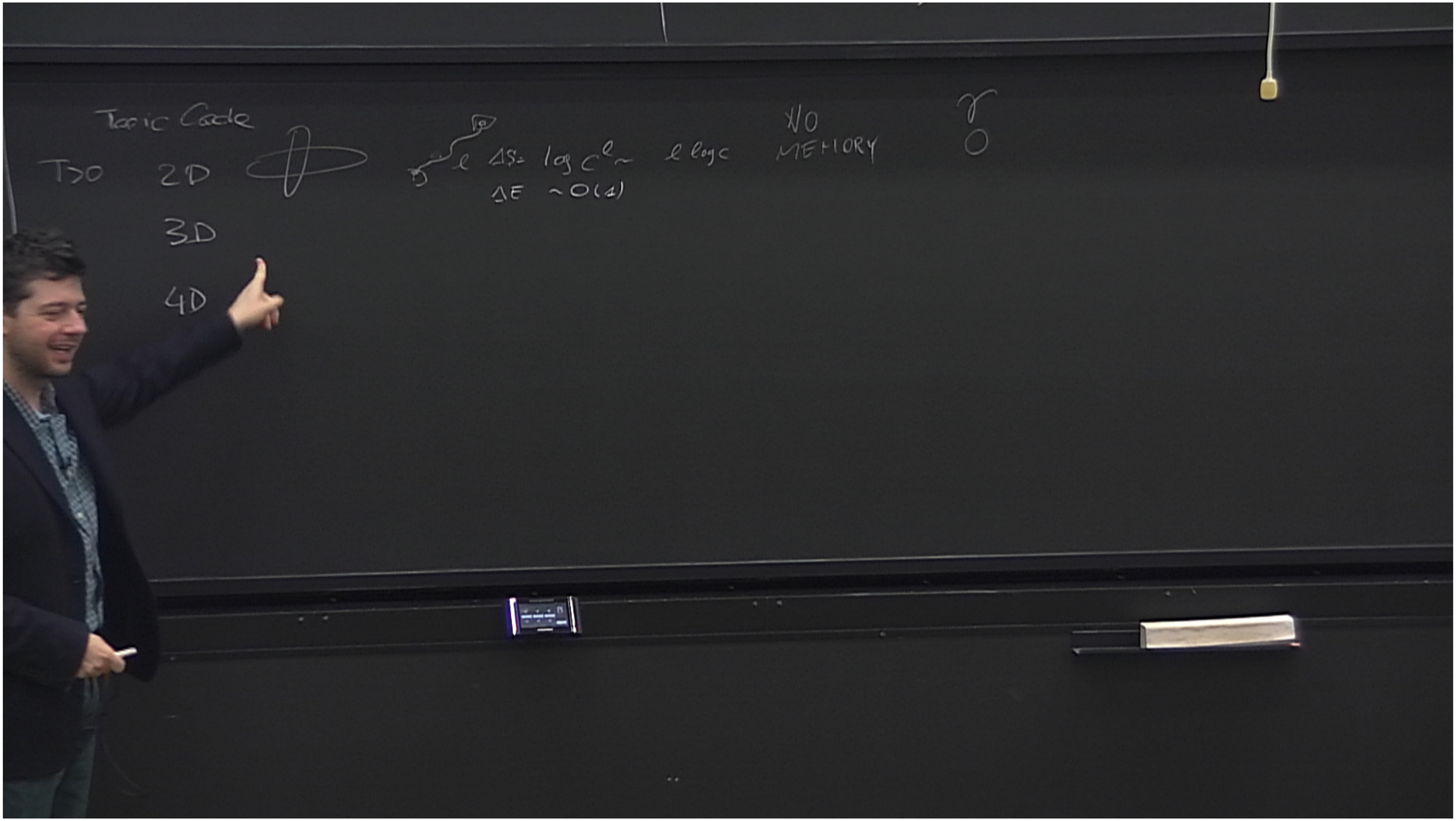
$\rho_0 \longrightarrow \frac{e^{-\beta H_S}}{Z_1}$
$\Delta F \sim n$
F
$\Delta F = \Delta E - T\Delta S$
finite
ext.
x
$|0\rangle \longrightarrow |1\rangle$
$e^{\Delta F} \sim e^{n}$
$|0\rangle + |1\rangle$
$|0\rangle - |1\rangle$

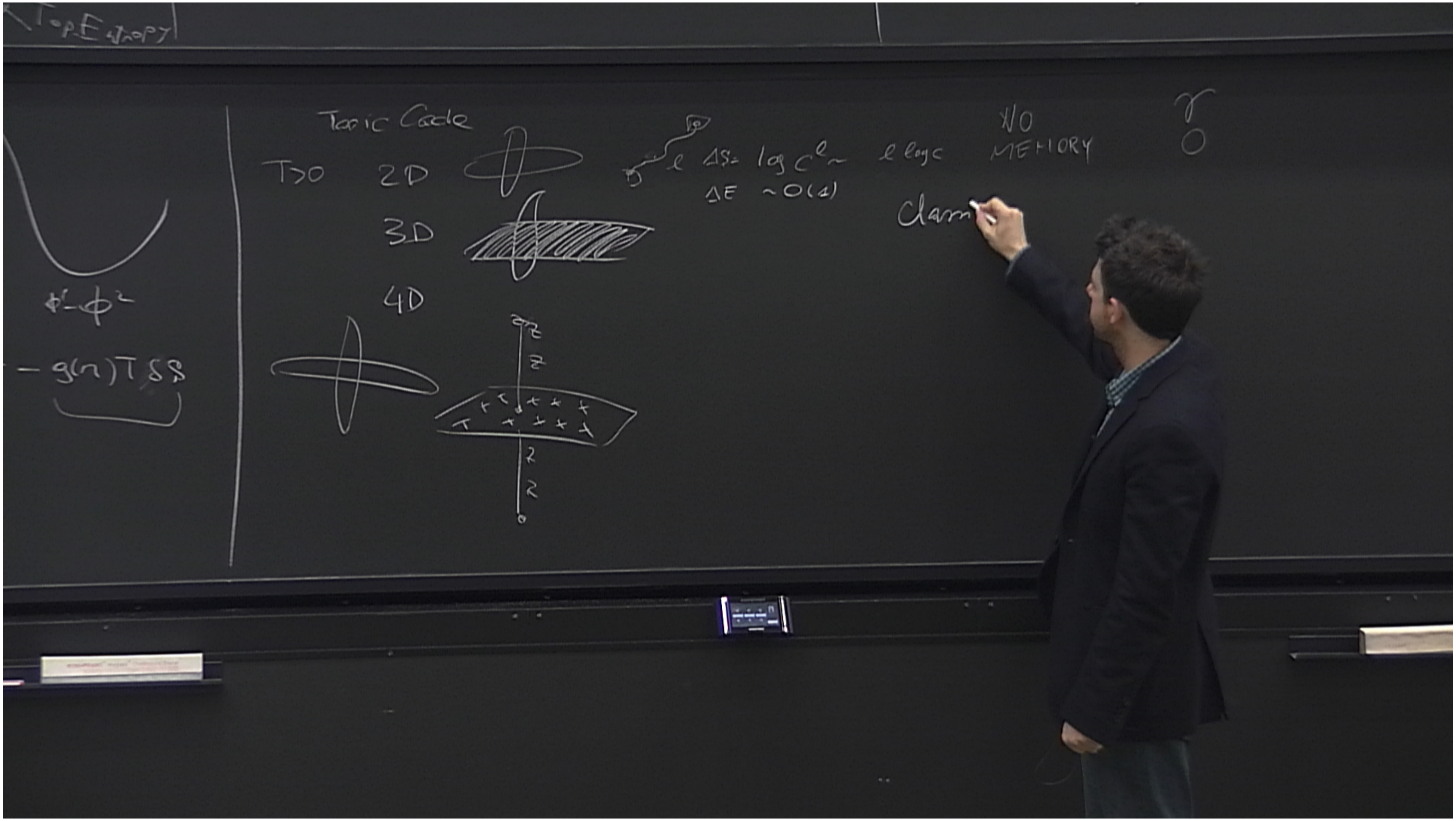

ϕ⁴+ϕ²
ϕ⁴−ϕ²
ΔF = f(n) ΔE − g(n) T δS

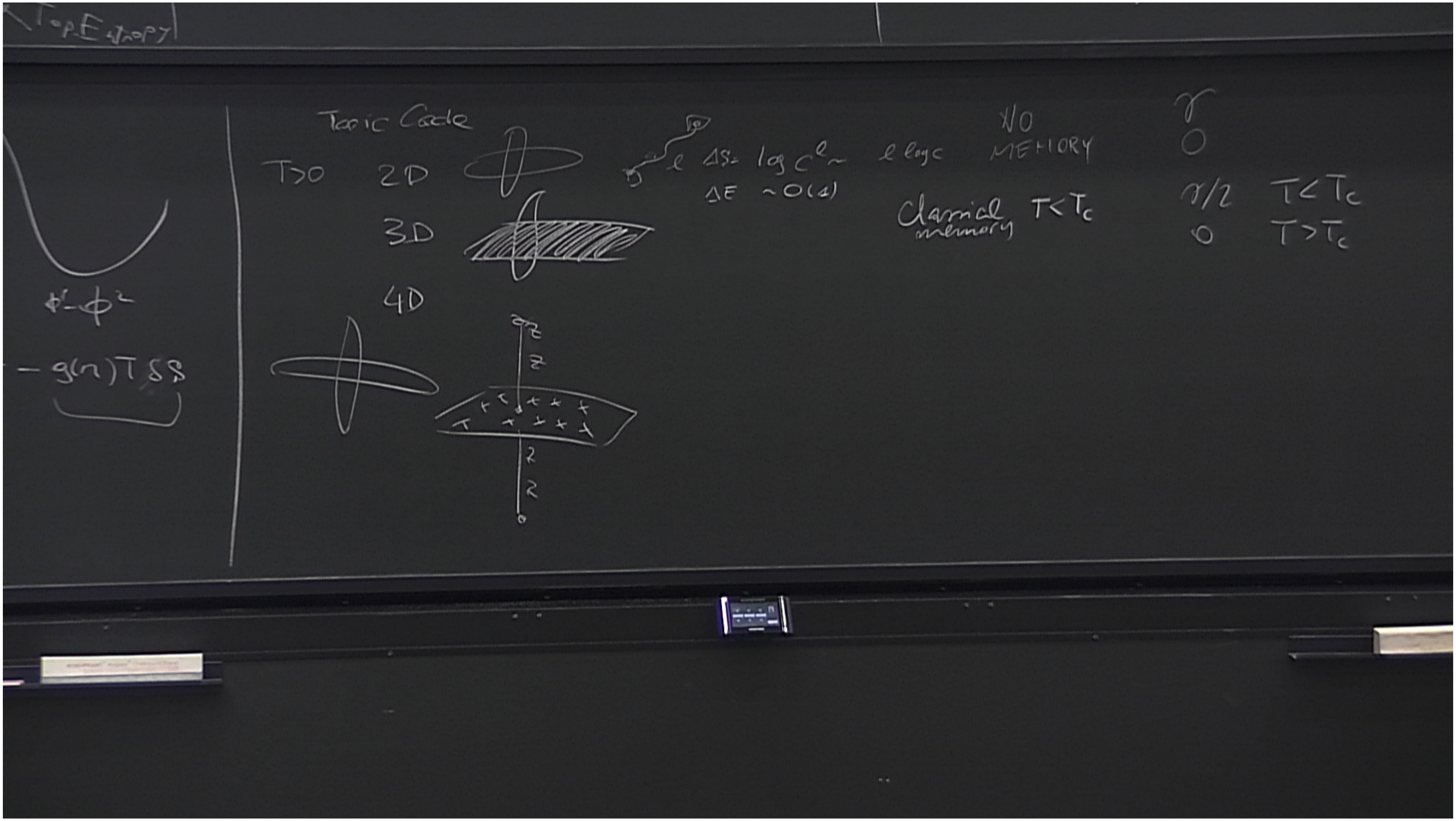

Toric Code
2D
3D
4D
ΔF = f(n)ΔE − g(n)TδS

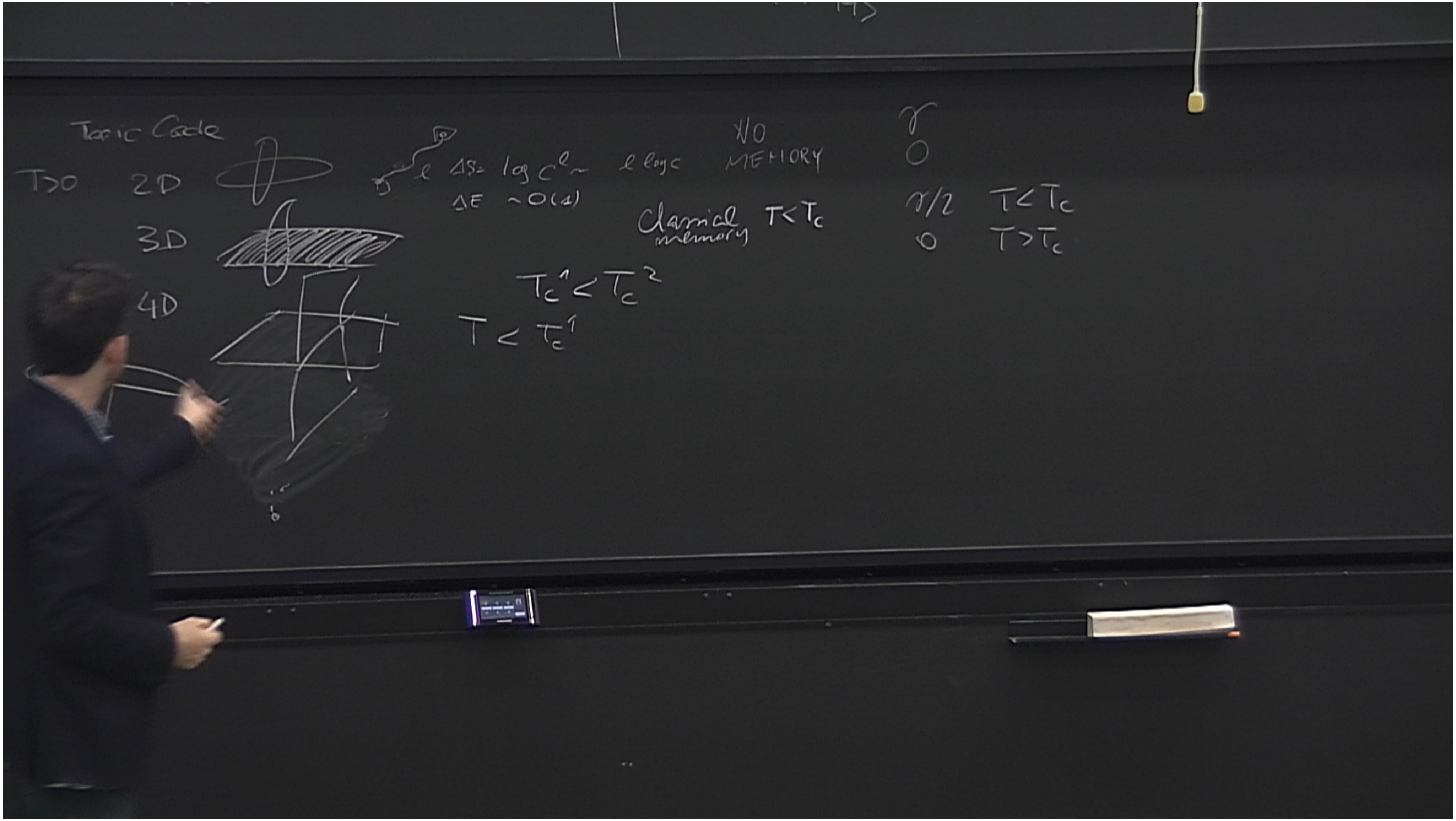

Toric Code
2D
3D
4D
ΔS= log c^l ~ l log c
ΔE ~ O(1)
ΔF =
− g(n) T δS

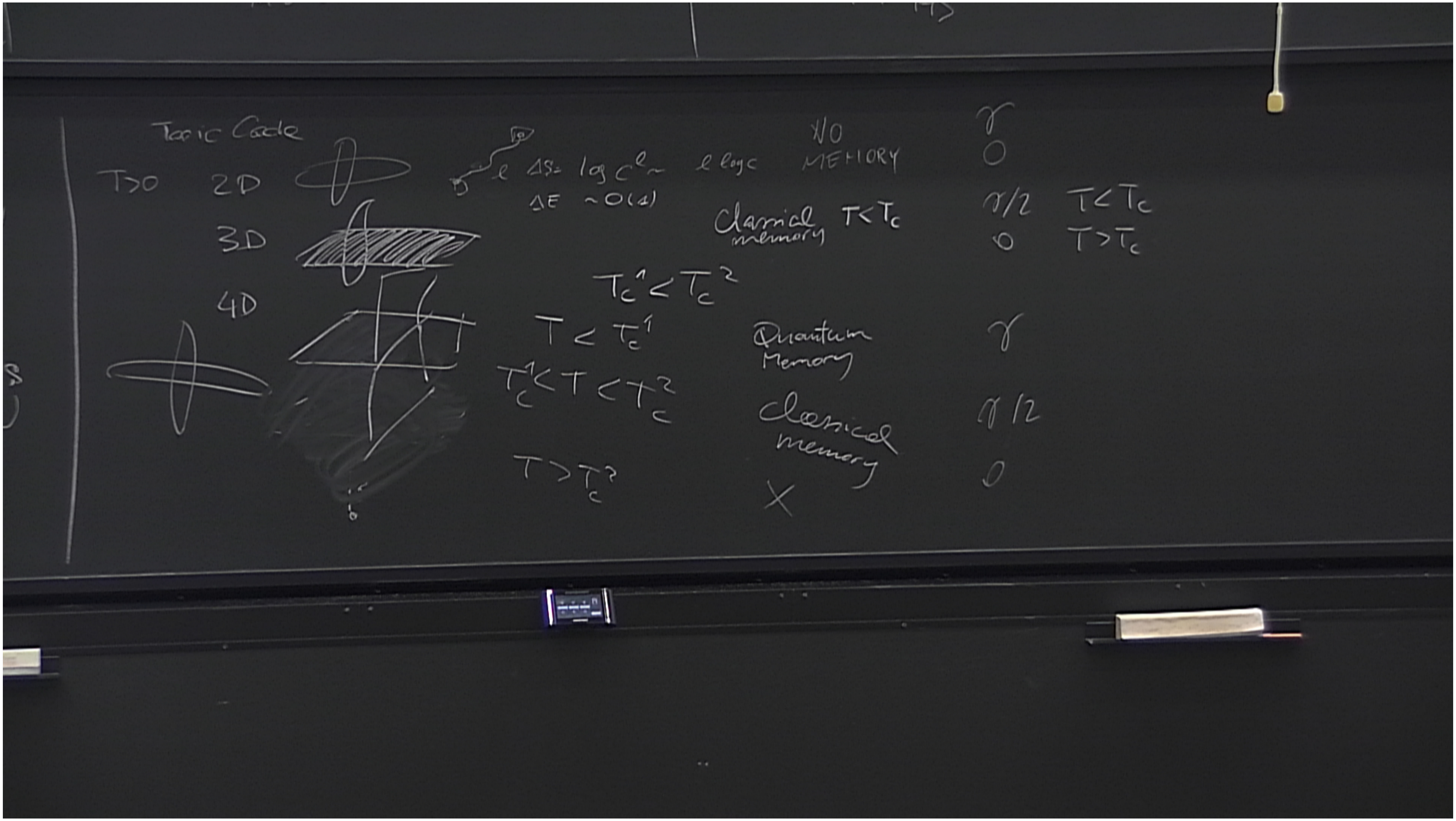

Toric Code
2D
3D
4D
ΔS= log c^l ~ l log c
ΔE ~ O(1)
NO
MEMORY

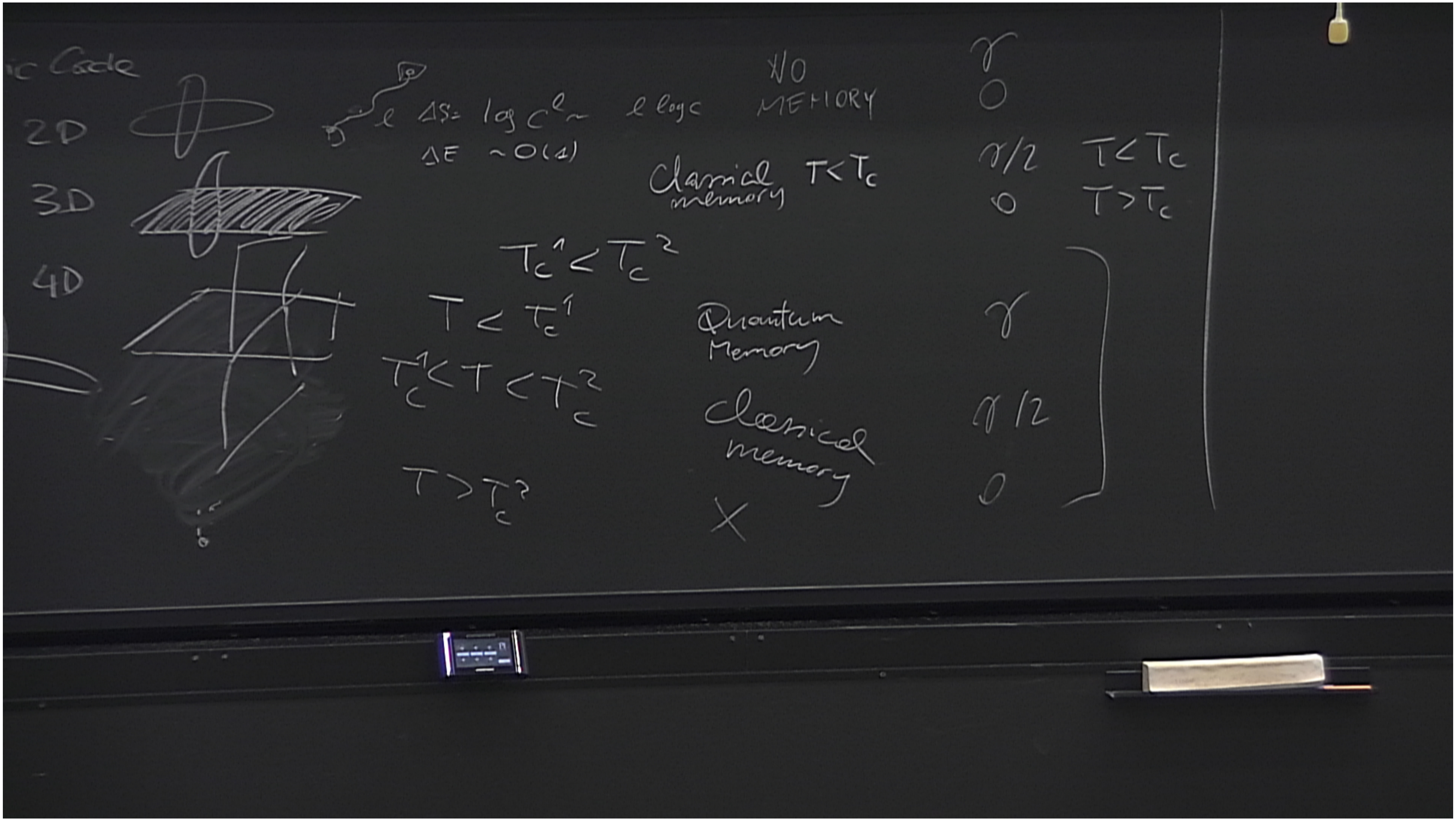

Toric Code
T>0
2D
3D
4D
ΔS = log c^ℓ ~ ℓ log c
ΔE ~ O(1)
No MEMORY

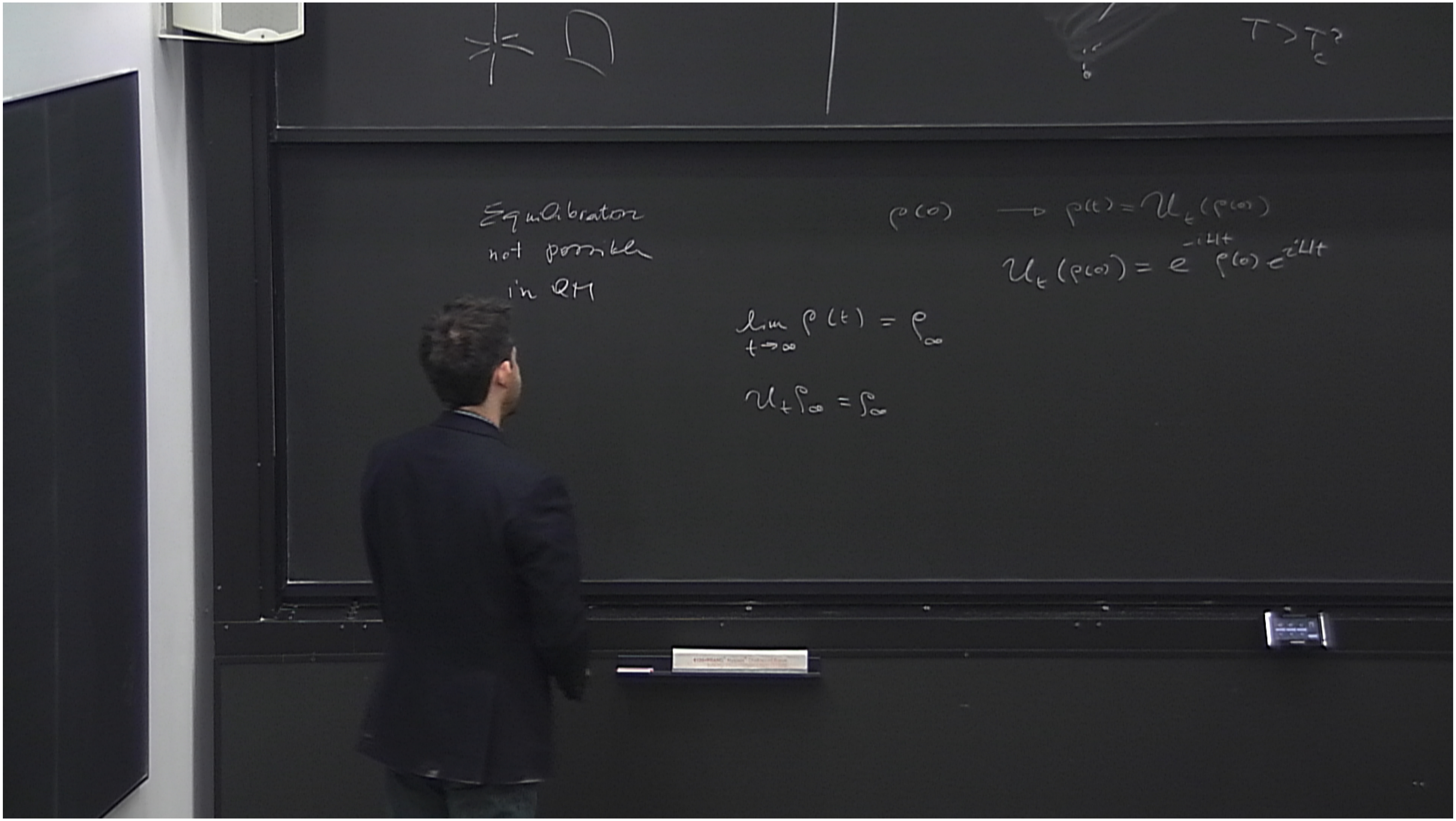

Top Entropy
Toric Code
T>0
2D
3D
4D
ΔS= log c^l ~ l log c
ΔE ~ O(1)
W/O MEMORY
Classi
ϕ⁴−ϕ²
−g(n) T δS


Top Entropy
Toric Code
T>0
2D
3D
4D
ΔS= log c^l ~ l log c
ΔE ~ O(1)
NO MEMORY
Classical memory
T<Tc
γ
0
γ/2 T<Tc
0 T>Tc
φ⁴−φ²
−g(n)TδS

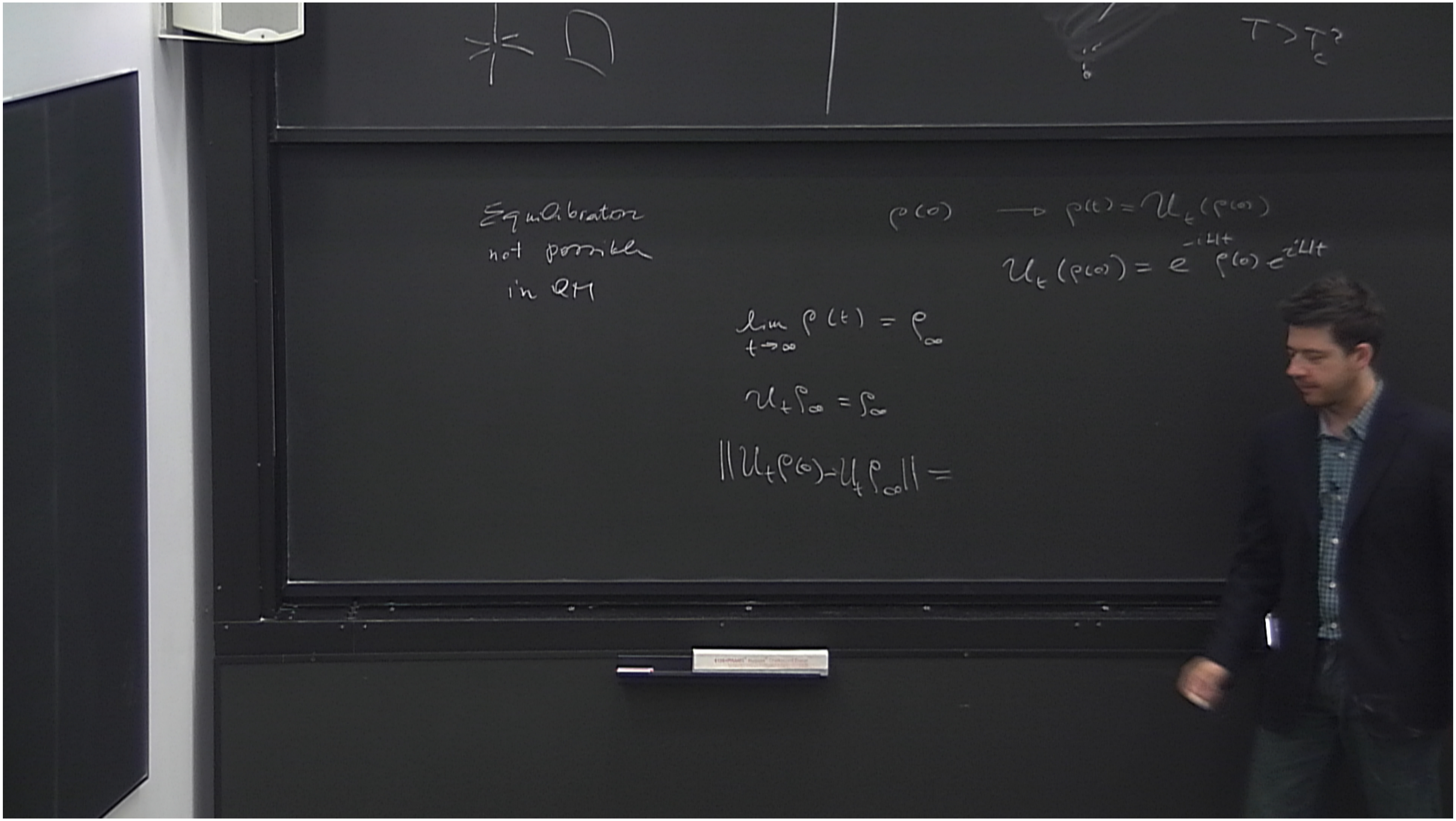

Toric Code
T>0
2D
3D
4D
ΔS = log c^l ~ l log c
ΔE ~ O(1)
W/O
MEMORY
Classical memory T<Tc
Tc^1 < Tc^2
T < Tc^1
γ
0
γ/2 T<Tc
0 T>Tc

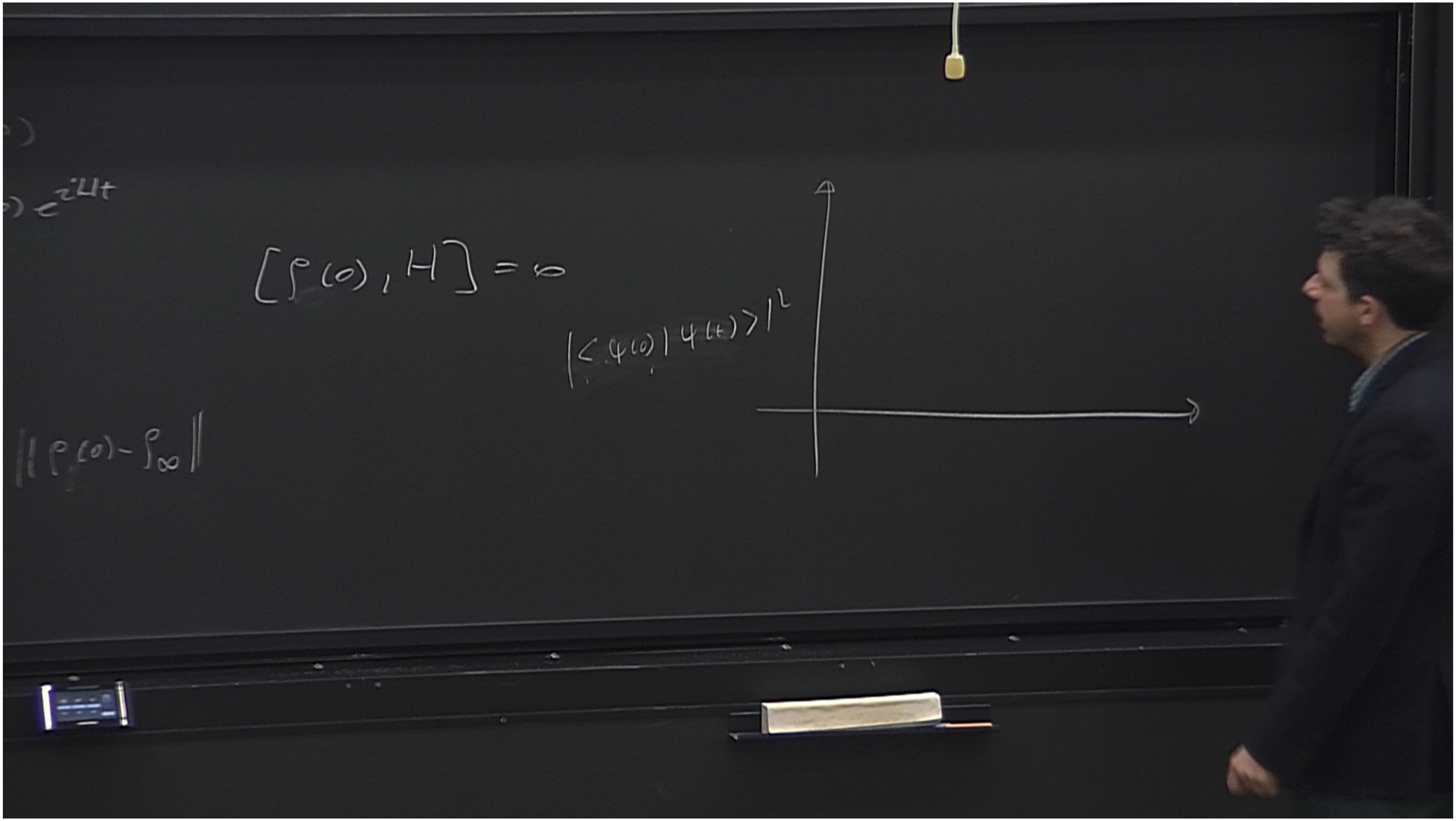

Toric Code
T>0
2D
3D
4D
ΔS= log c^l ~ l log c
ΔE ~ O(1)
NO MEMORY
Classical memory
T<T_c
T_c^1 < T_c^2
T < T_c^1
T_c^1 < T < T_c^2
T > T_c^2
Quantum Memory
classical memory
γ
0
γ/2
T<T_c
0
T>T_c
γ
γ/2
0

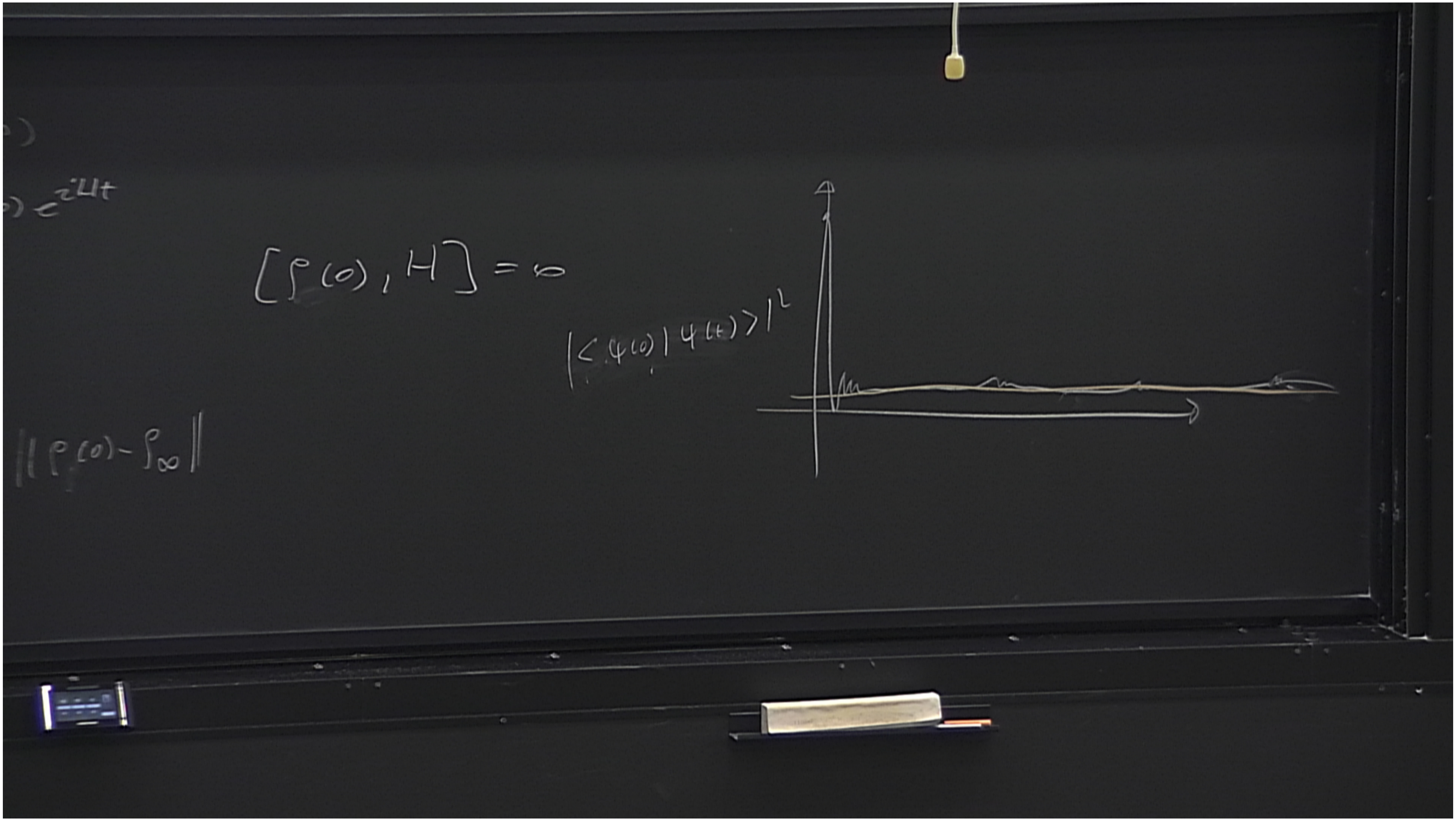

ic Code
2D
3D
4D
$\Delta S = \log c^{\ell} \sim \ell \log c$
$\Delta E \sim O(1)$
NO MEMORY
γ
0
Classical memory $T < T_c$
$\gamma/2$ $T < T_c$
0 $T > T_c$
$T_c^1 < T_c^2$
$T < T_c^1$
Quantum Memory
γ
$T_c^1 < T < T_c^2$
classical memory
$\gamma/2$
$T > T_c^2$
X
0



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


$T > T_c$?
Equilibration
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_∞||


e^{iHt}
$[\rho(0), H] = 0$
$|\langle \psi(0)|\psi(t)\rangle|^2$
$\|\rho(0) - \rho_\infty\|$