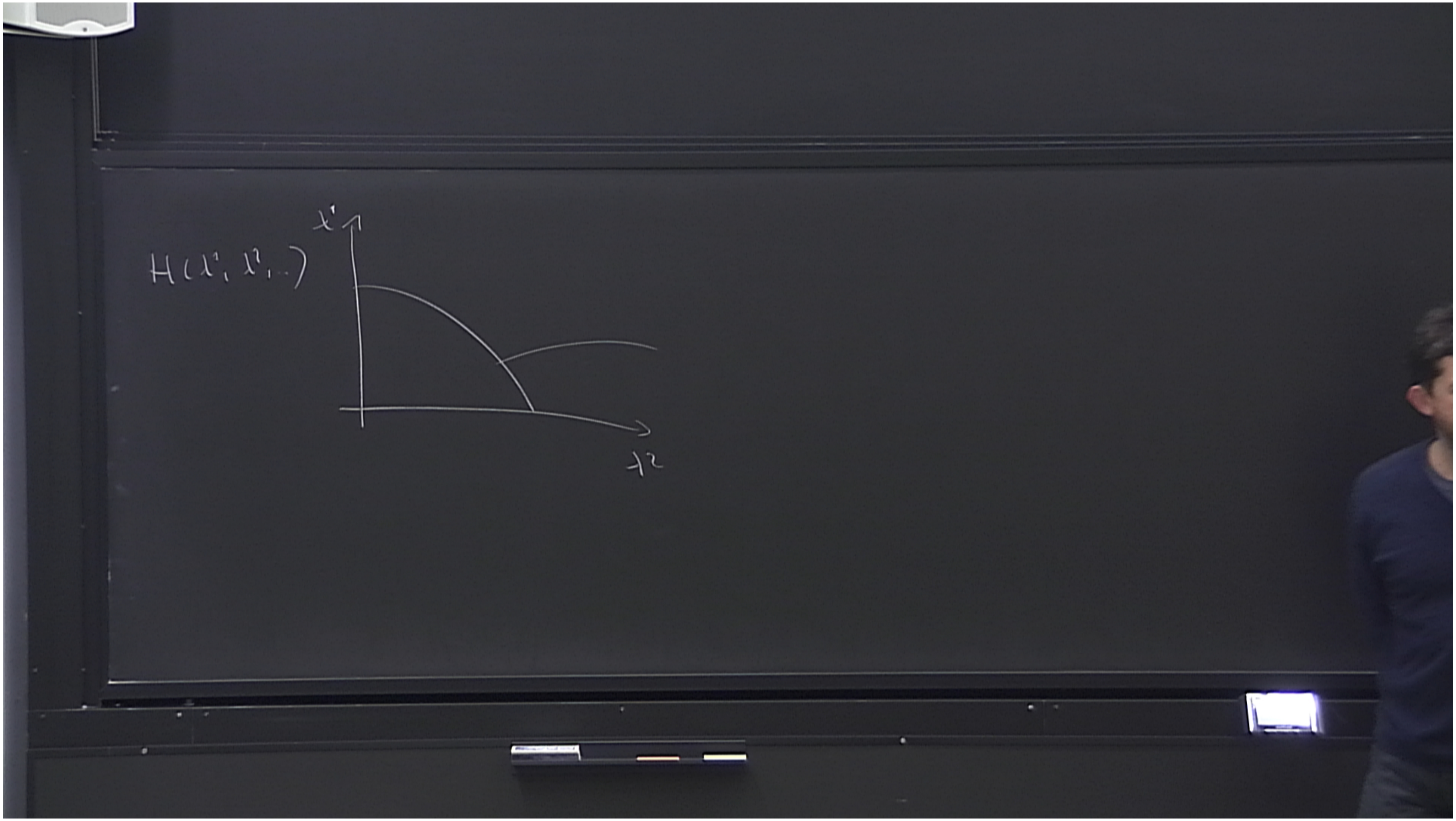
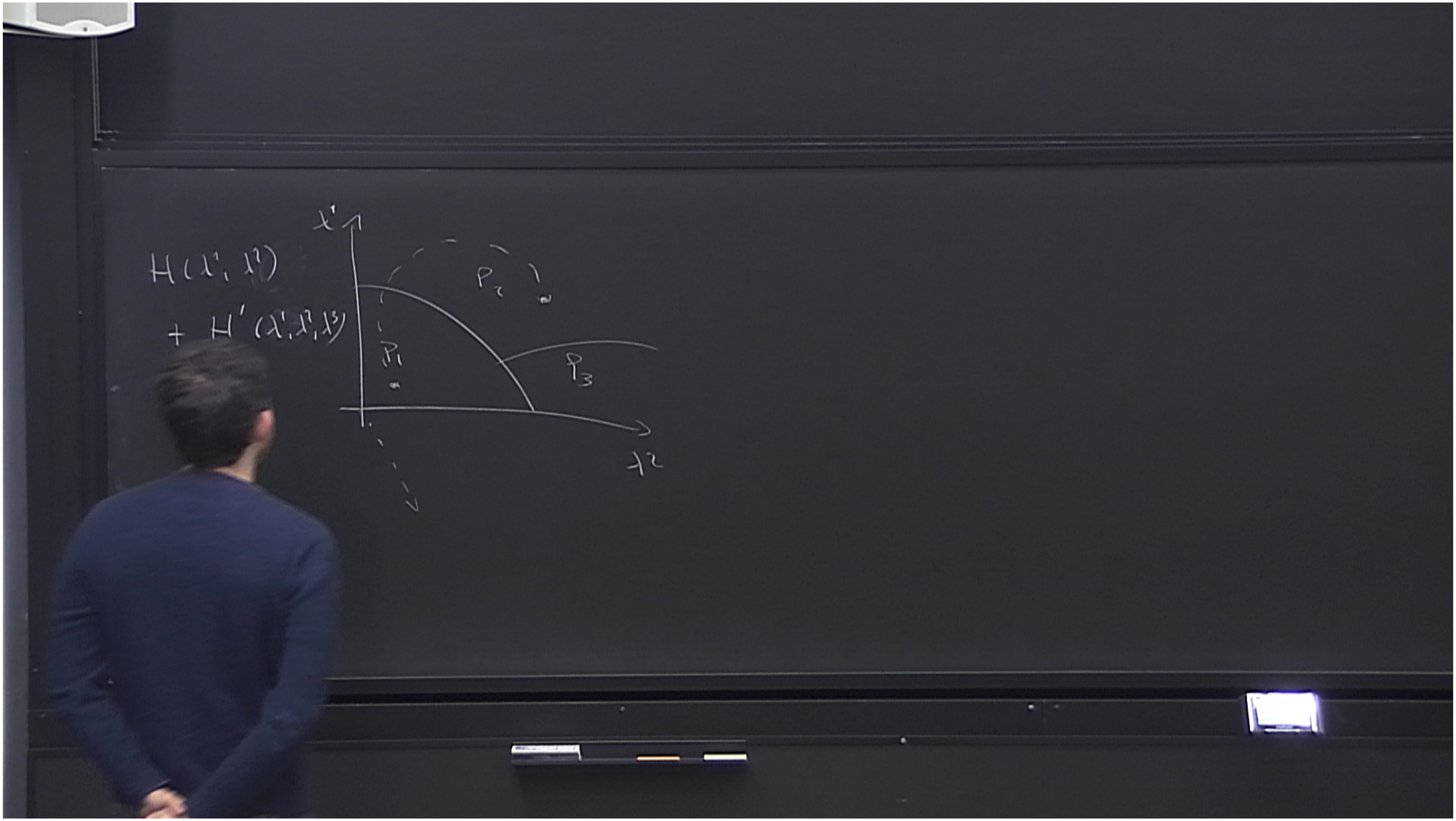
Title: Condensed Matter Review-2

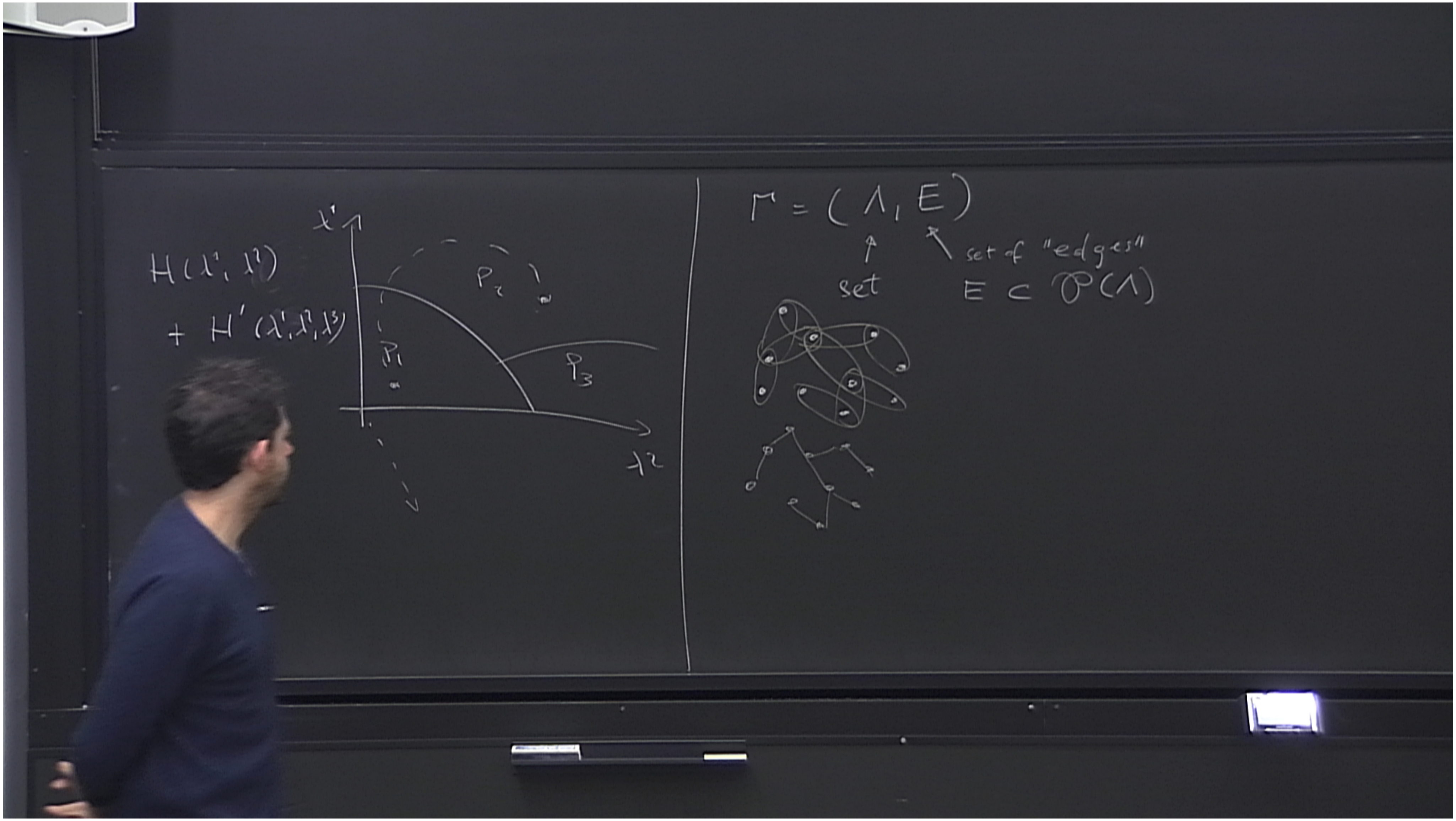
Date: Jan 27, 2015 09:00 AM

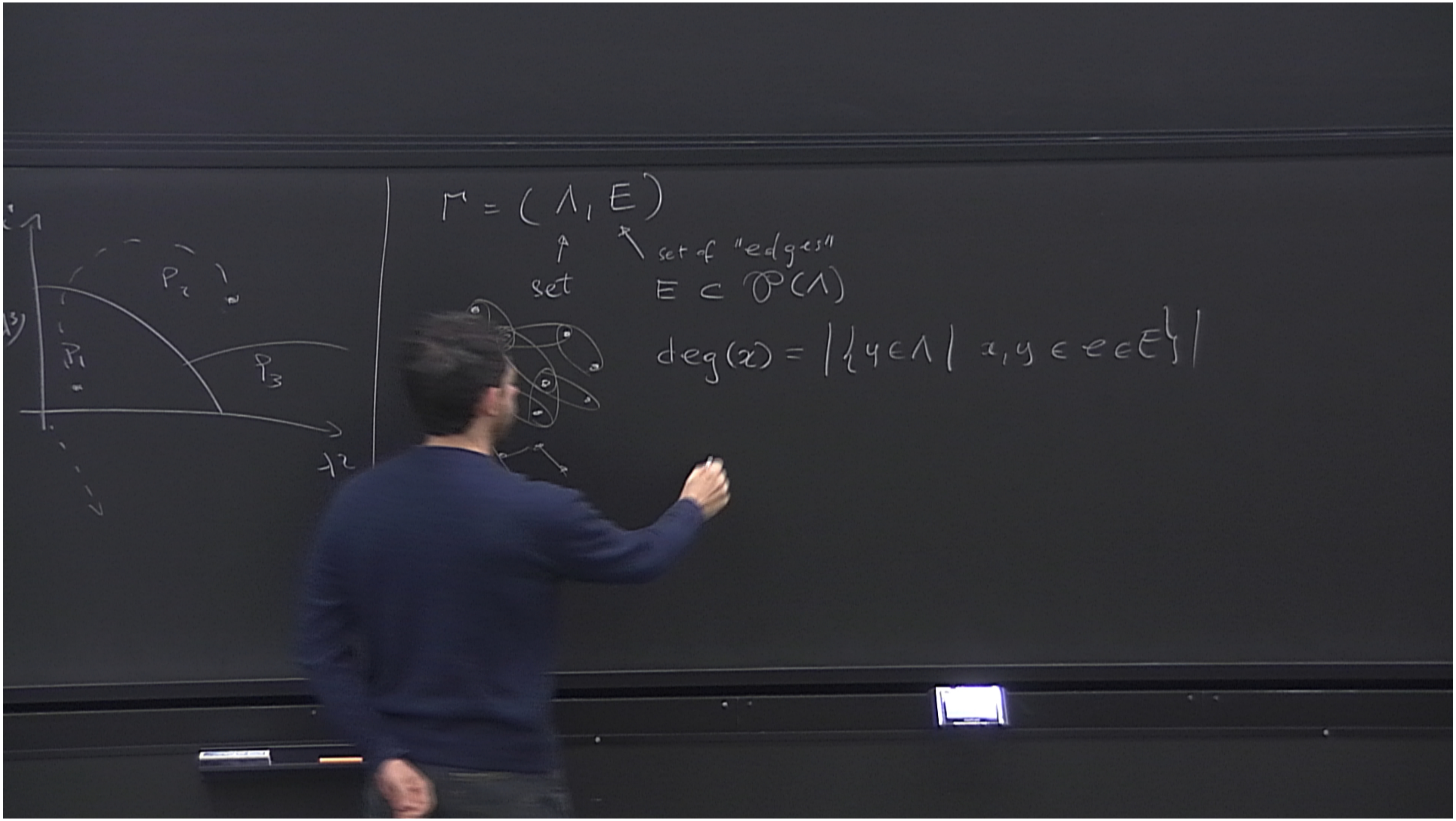
URL: http://pirsa.org/15010058

Abstract:

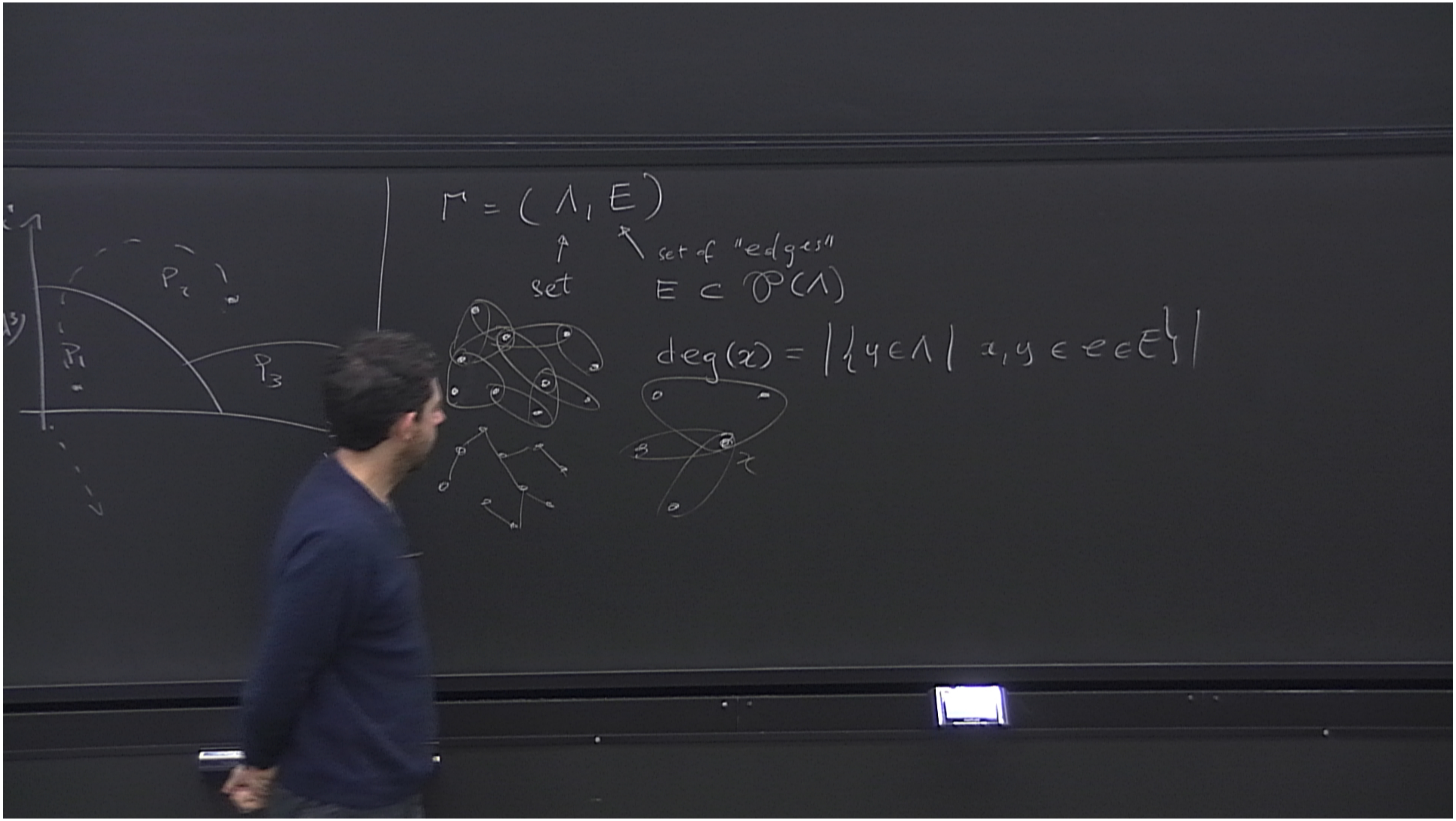


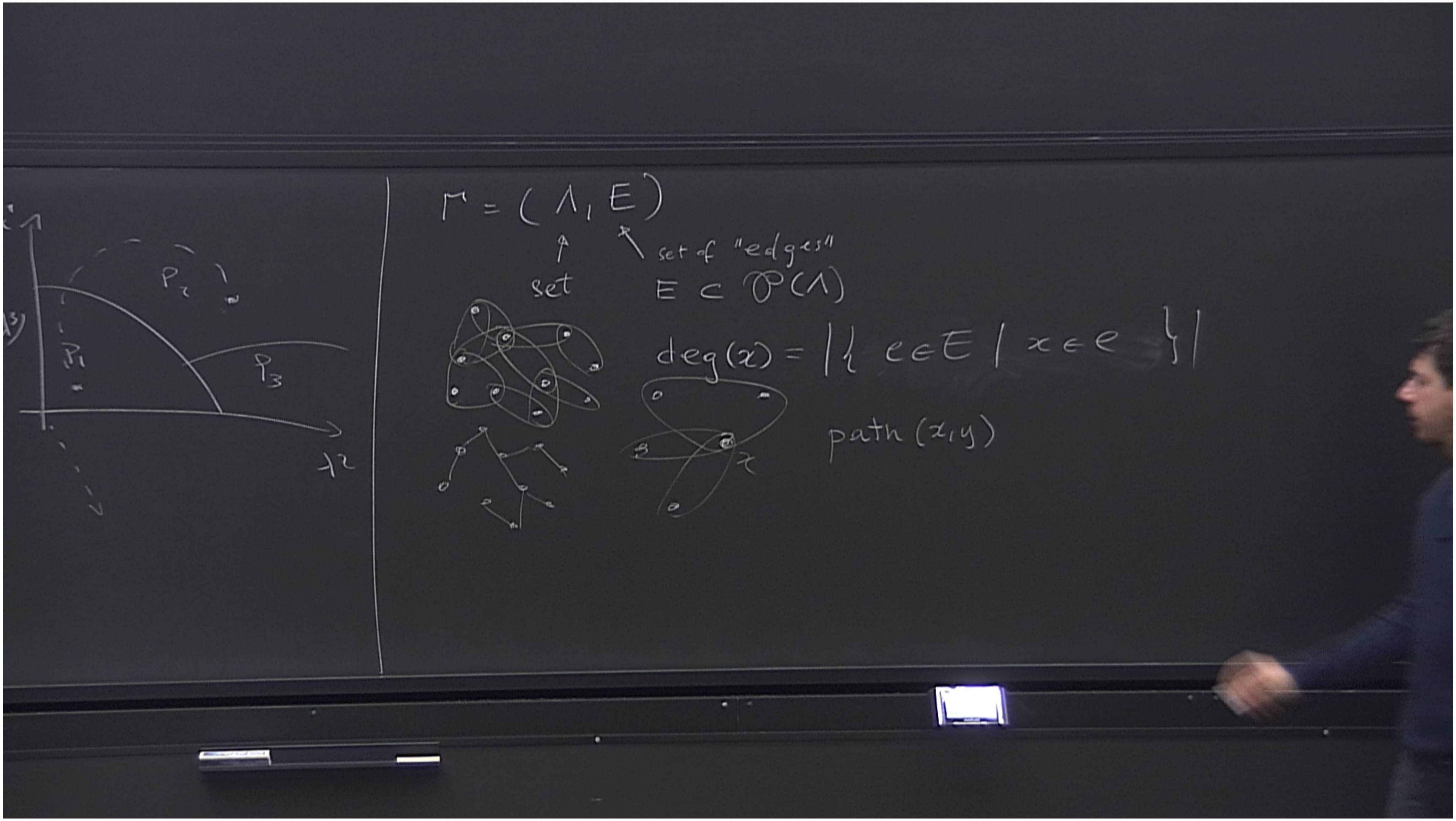

H(λ¹, λ²)
+ H′(λ¹, λ², λ³)
λ¹
λ²
P₁
P₂
P₃

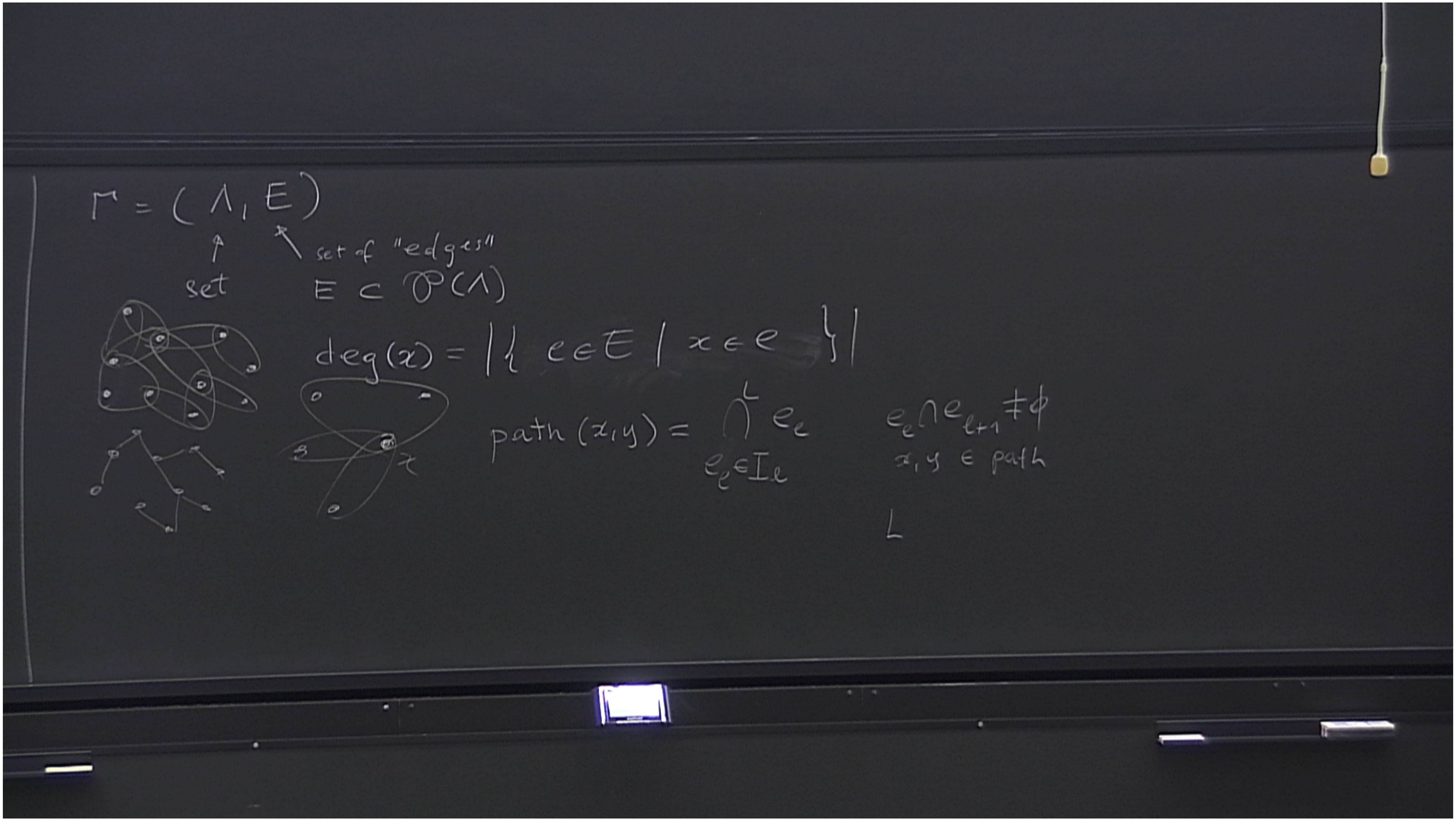

$H(\lambda^1, \lambda^2)$
$+ H'(\lambda^1, \lambda^2, \lambda^3)$
λ^1
λ^2
P_1
P_2
P_3
$\Gamma = (\Lambda, E)$
set
set of "edges"
$E \subset \mathcal{P}(\Lambda)$

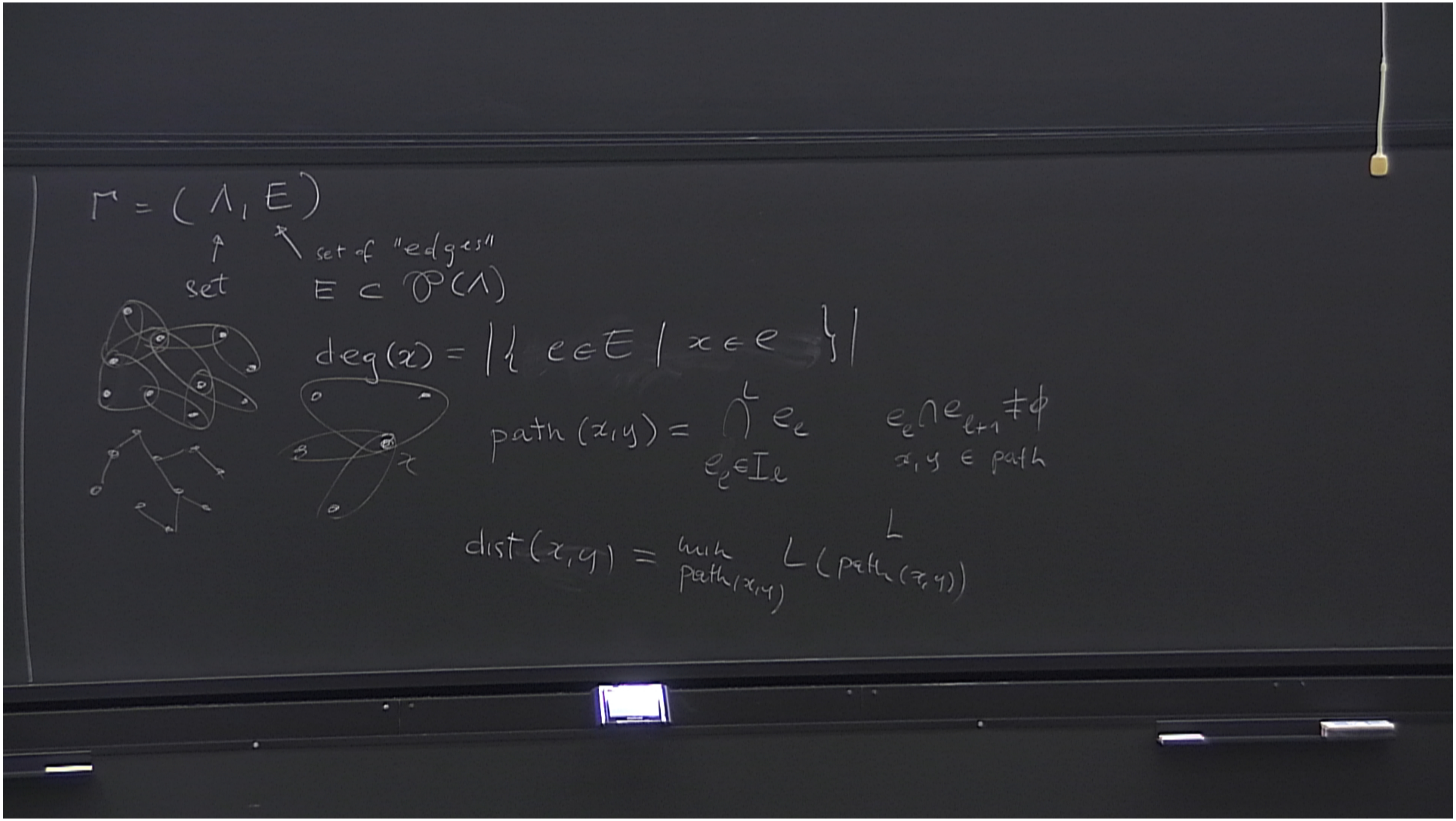


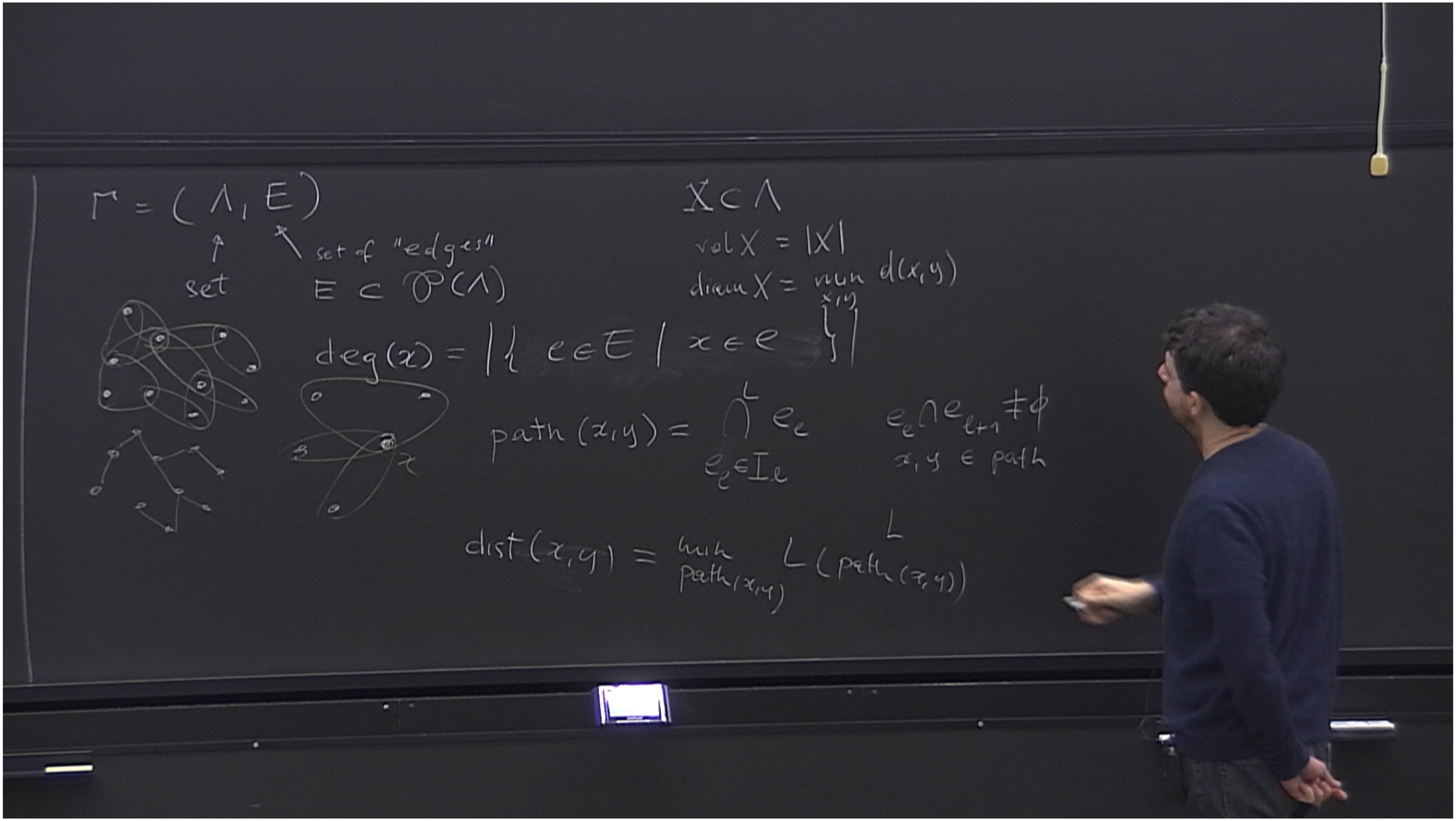
Γ = (Λ, E)
set
set of "edges"
E ⊂ ℘(Λ)
deg(x) = |{y ∈ Λ | x, y ∈ e ∈ E}|
P1
P2
P3

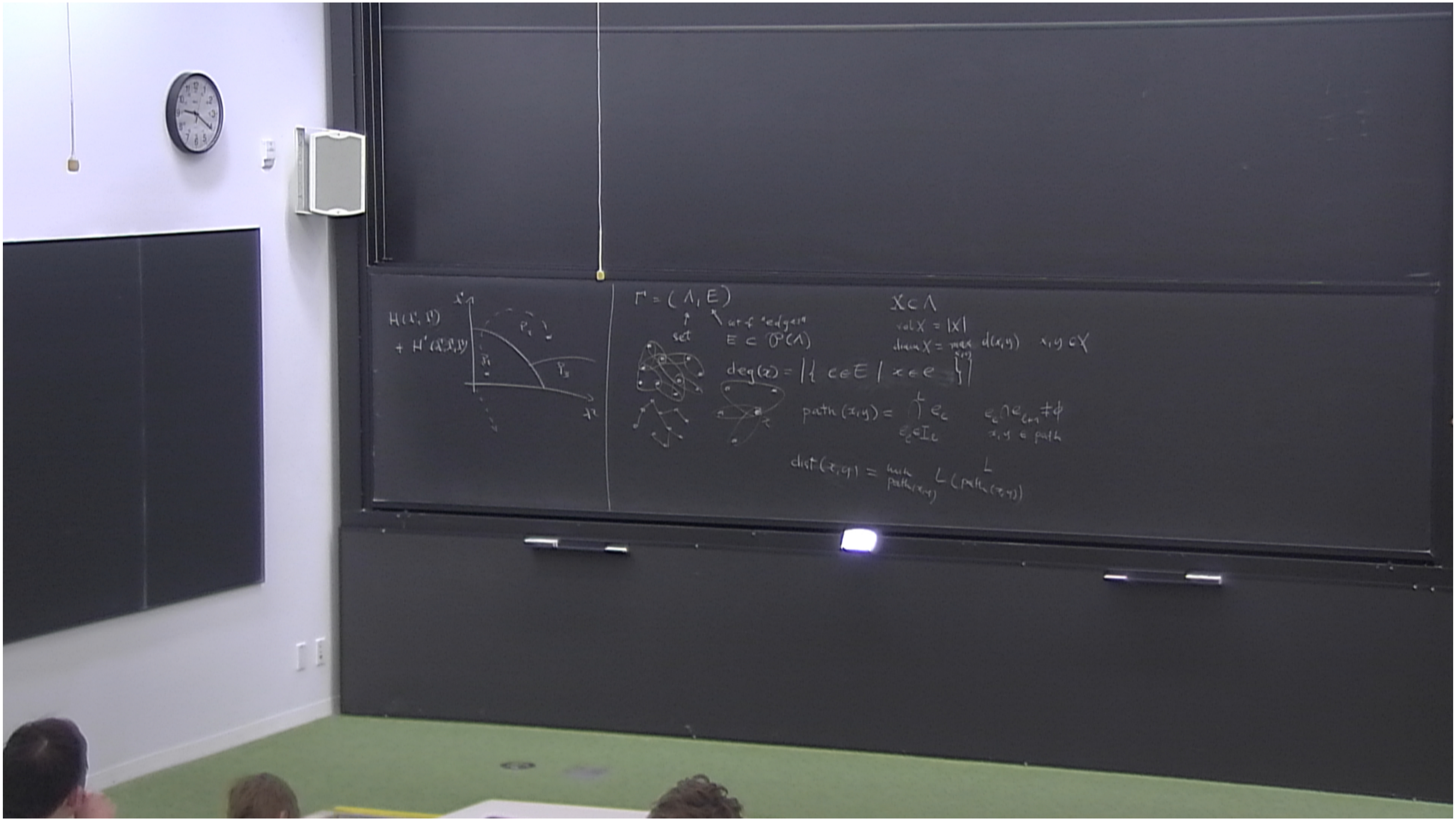

Γ = (Λ, E)
set
set of "edges"
E ⊂ ℘(Λ)
deg(x) = |{y ∈ Λ | x, y ∈ e ∈ E}|
P₁
P₂
P₃
x

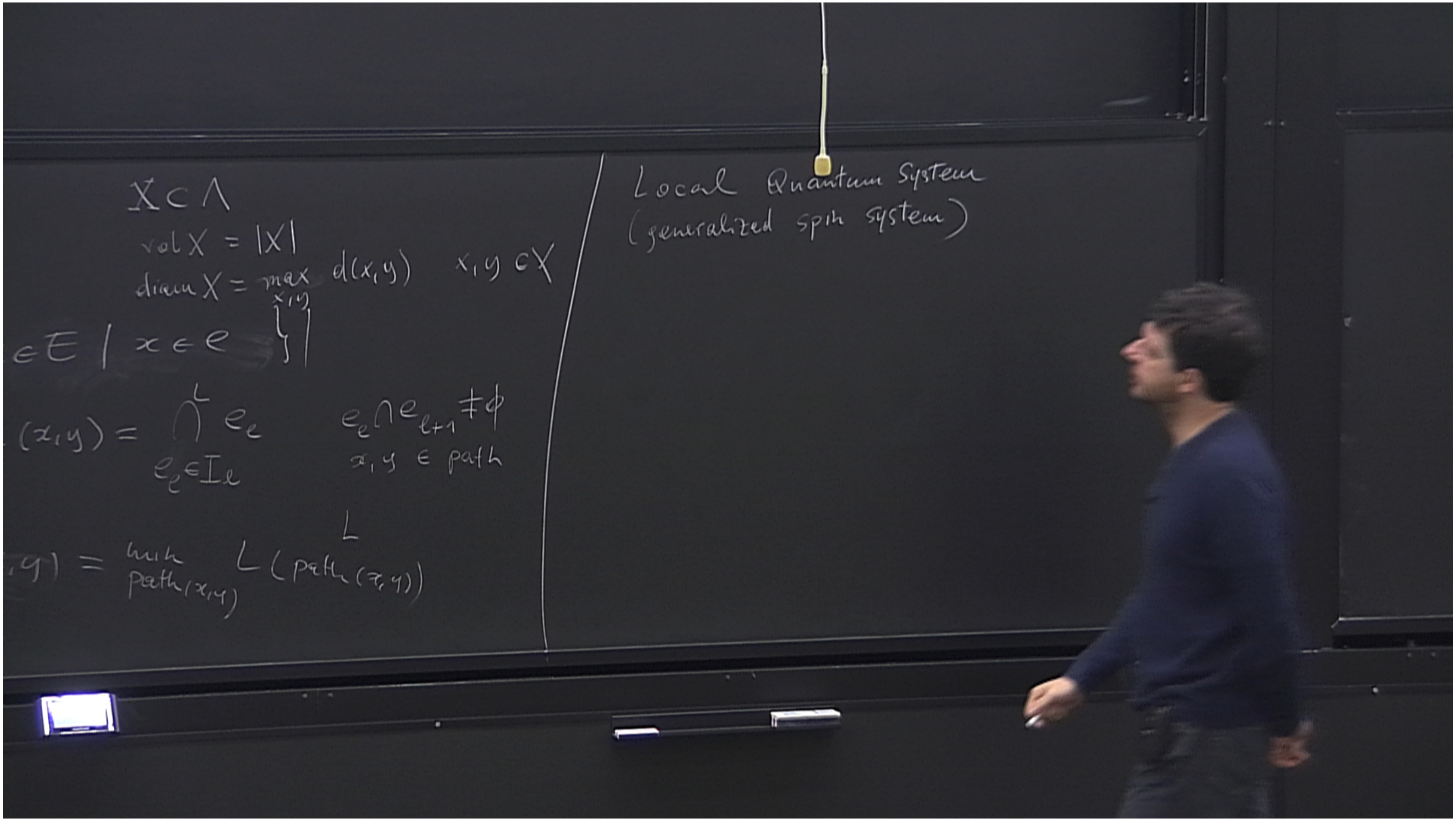

$\Gamma = (\Lambda, E)$
set
set of "edges"
$E \subset \mathcal{P}(\Lambda)$
$\deg(x) = |\{ e \in E \mid x \in e \}|$
path (x, y)
P_1
P_2
P_3


Γ = (Λ, E)
set
set of "edges"
E ⊂ 𝒫(Λ)
deg(x) = |{ e∈E | x∈e }|
path(x,y) = ⋂ e_ℓ
L
e_ℓ∈I_ℓ
e_ℓ ∩ e_ℓ+1 ≠ φ
x, y ∈ path
L

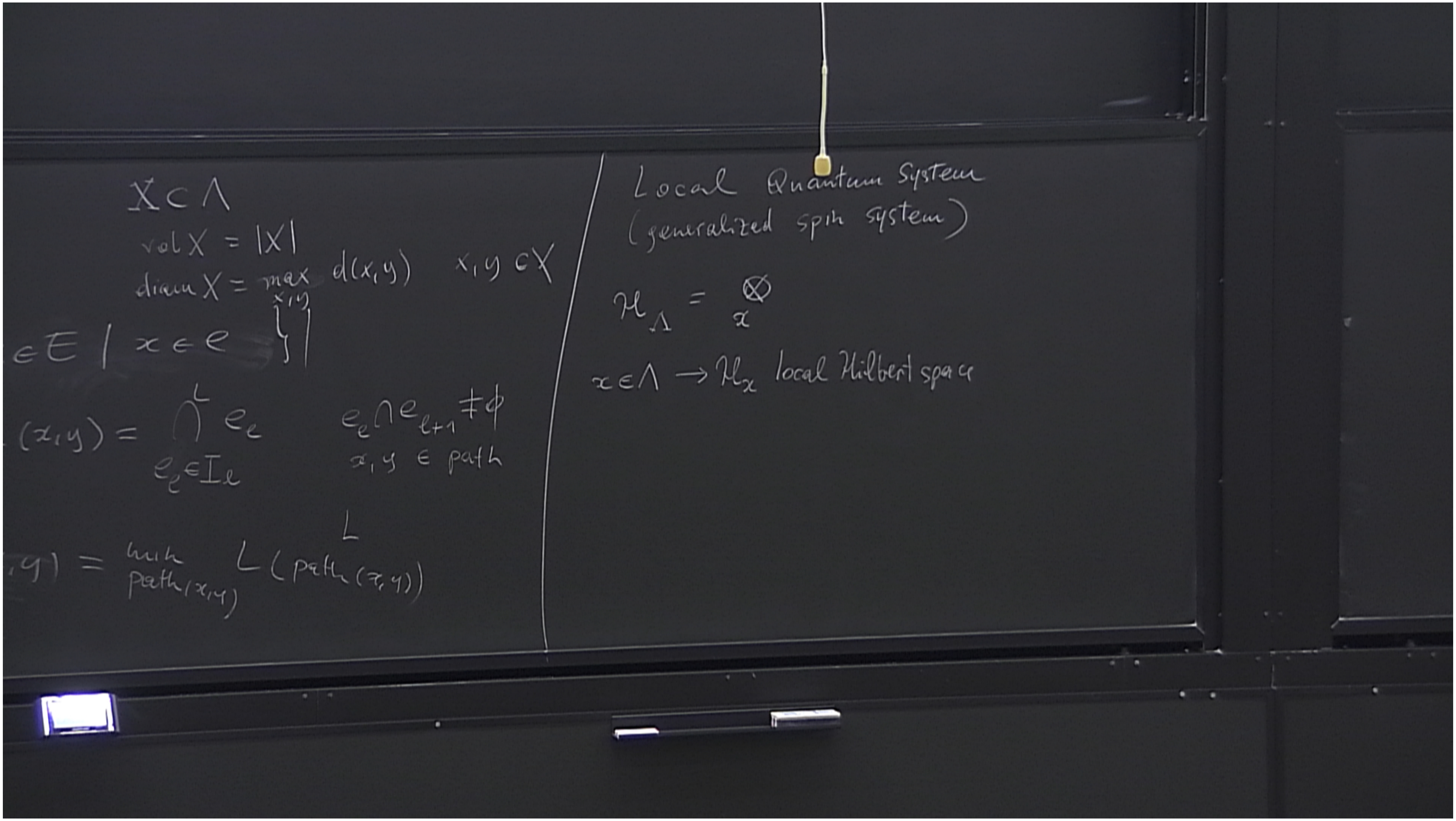

Γ = (Λ, E)
set
set of "edges"
E ⊂ 𝒫(Λ)
deg(x) = |{ e∈E | x∈e }|
path(x,y) = ⋂ e_ℓ
e_ℓ∈I_ℓ
e_ℓ ∩ e_{ℓ+1} ≠ φ
x, y ∈ path
dist(x,y) = min L(path(x,y))
path(x,y)

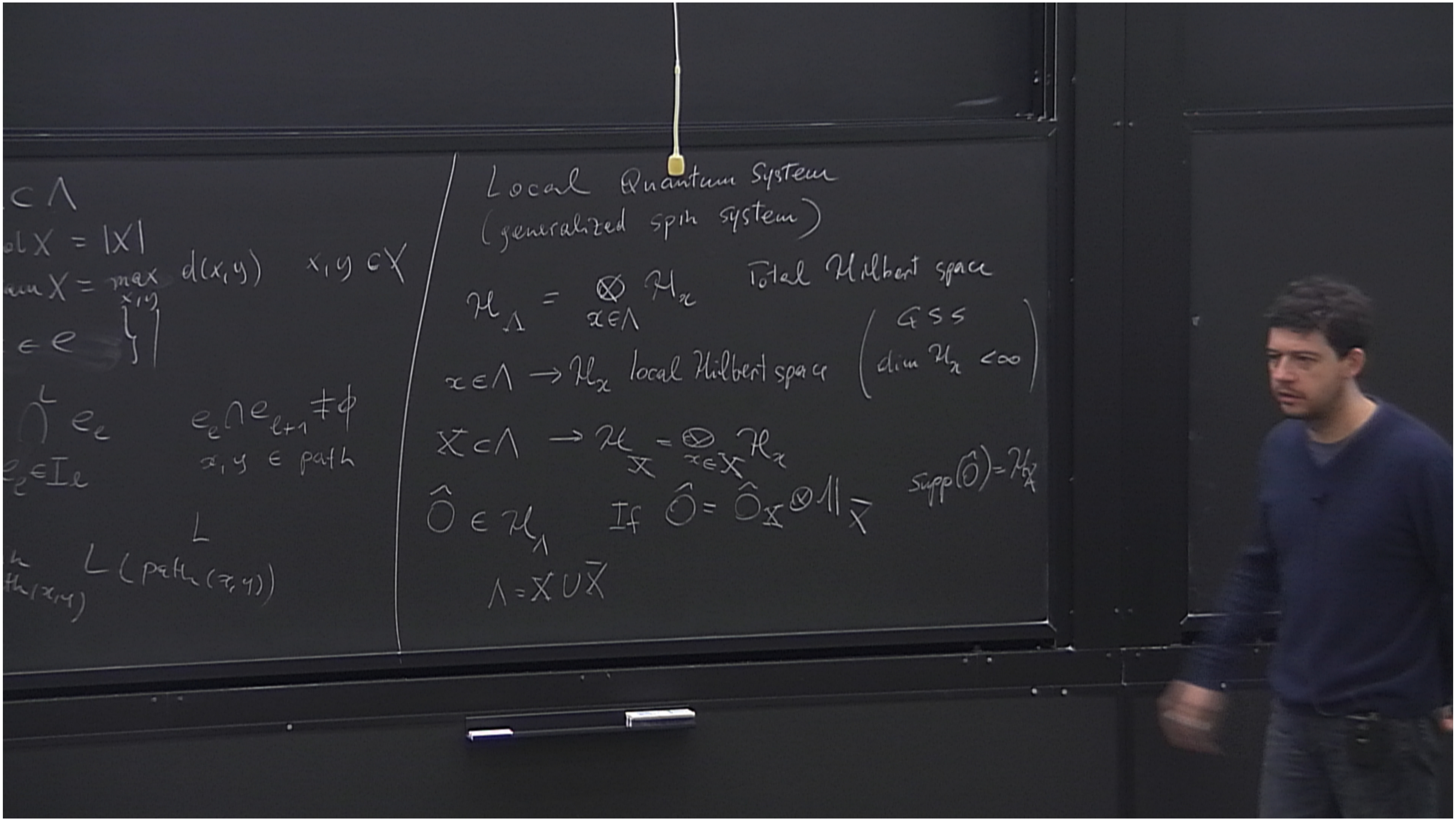

Γ = (Λ, E)
set
set of "edges"
E ⊂ ℘(Λ)
X ⊂ Λ
vol X = |X|
diam X = min d(x,y)
x,y
deg(x) = |{ e∈E | x∈e }|
path(x,y) = ∩ e_ℓ
L
e_ℓ∈I_ℓ
e_ℓ ∩ e_{ℓ+1} ≠ φ
x, y ∈ path
dist(x,y) = min L(path(x,y))
path(x,y)
L
x

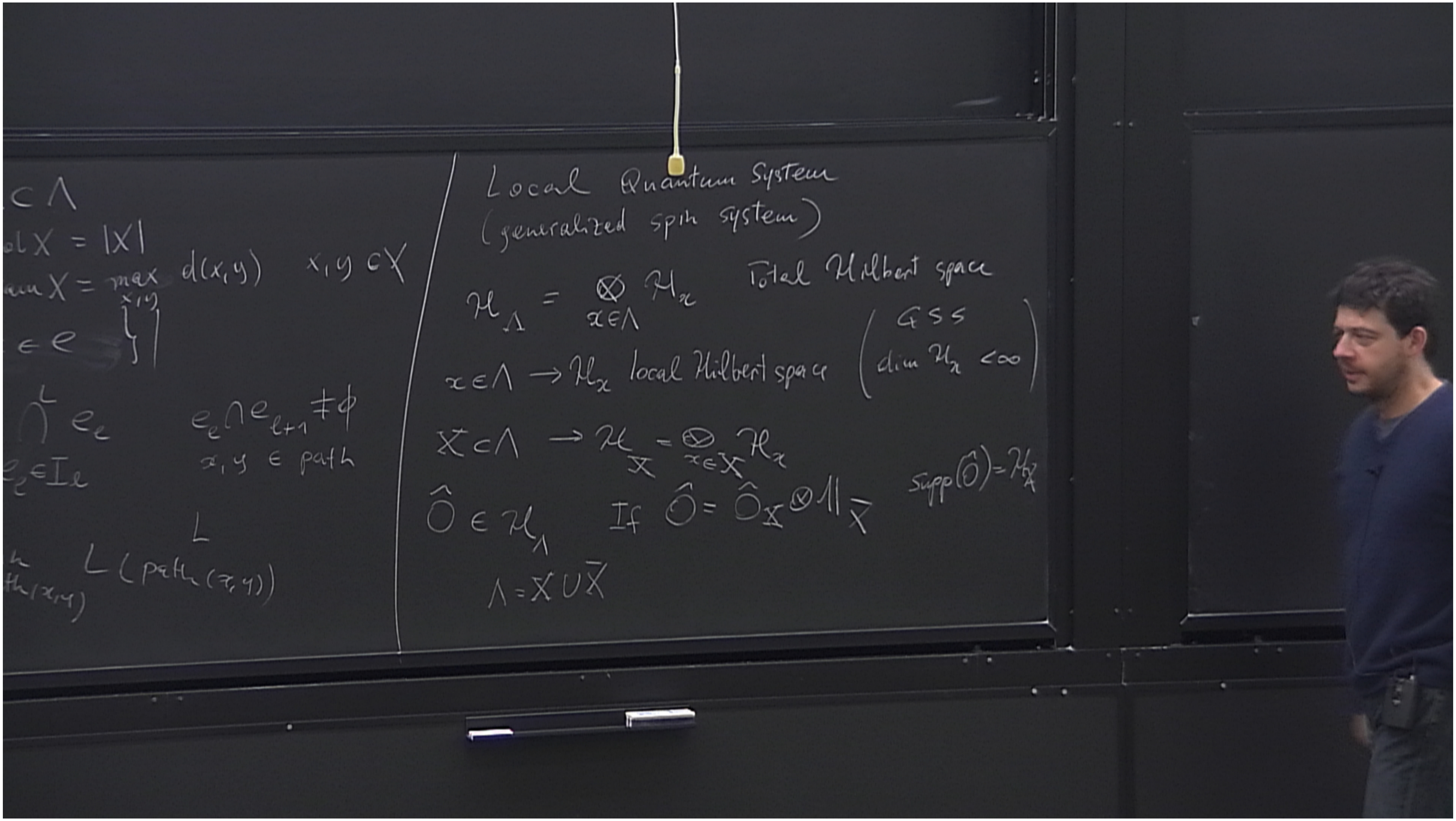

Γ = (Λ, E)
set of "edges"
set
E ⊂ P(Λ)
X ⊂ Λ
vol X = |X|
path (x,y) =
x,y ∈ path
dist (x,y) =

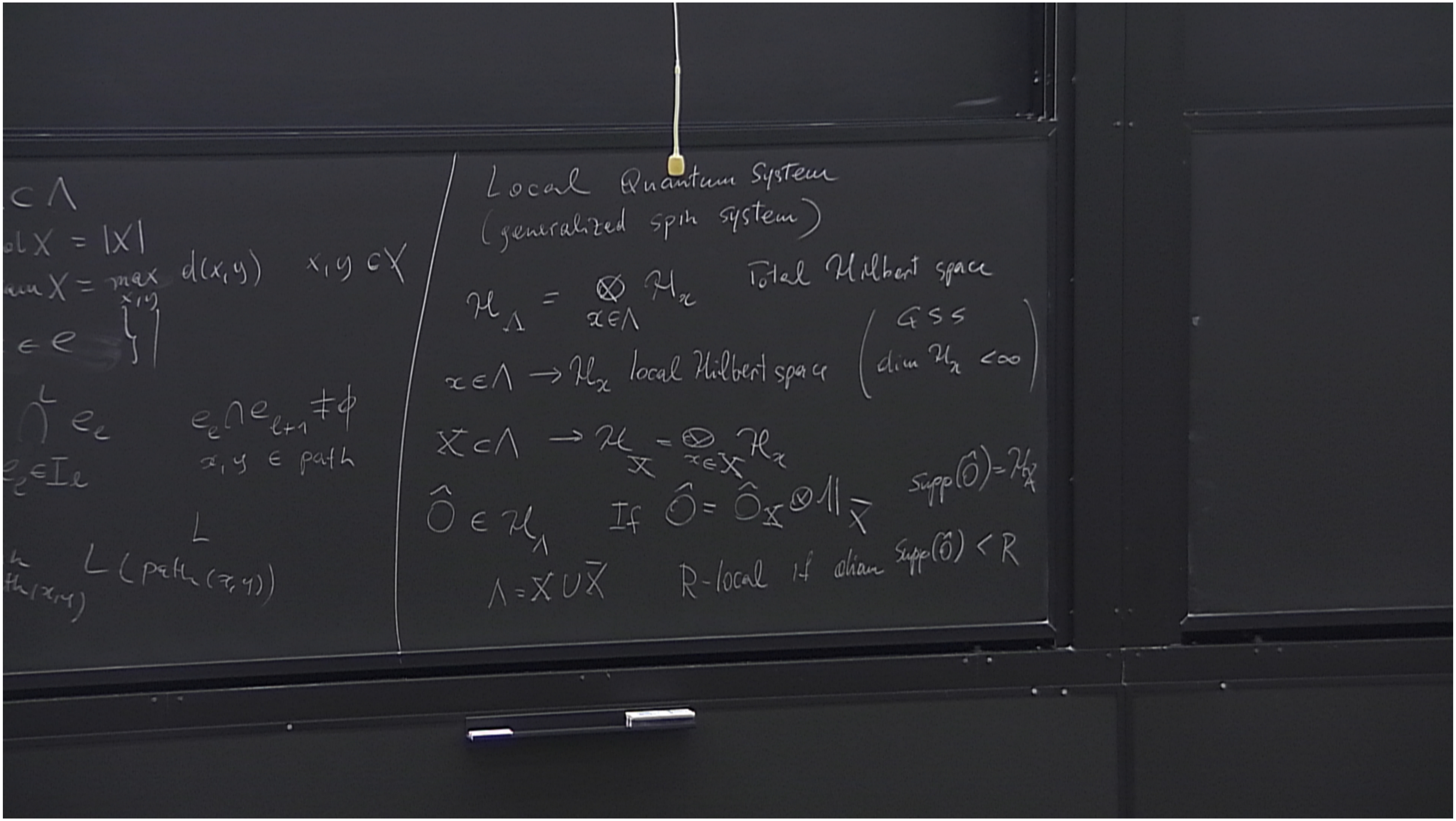


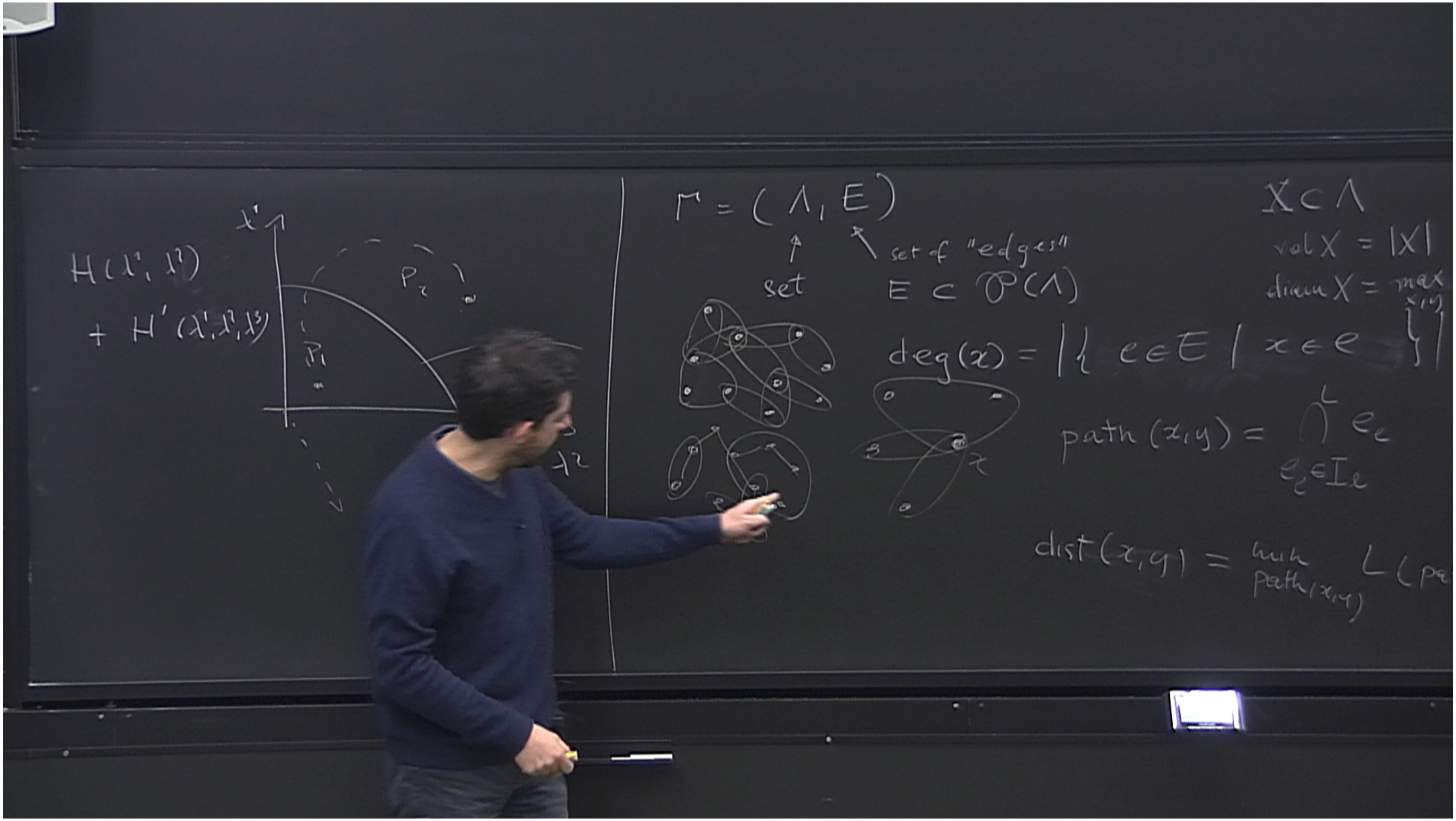
X ⊂ Λ
vol X = |X|
diam X = max d(x,y) x,y ∈ X
Local Quantum System
(generalized spin system)


X ⊂ Λ
vol X = |X|
diam X = max d(x,y) x,y ∈ X
x,y
∈ E | x ∈ e }|
(x,y) = ⋂ e_l
e_l ∈ I_l
e_l ∩ e_{l+1} ≠ φ
x,y ∈ path
L
,y) = min L (path (x,y))
path(x,y)
Local Quantum System
(generalized spin system)
H_Λ = ⊗
x
x ∈ Λ → H_x local Hilbert space

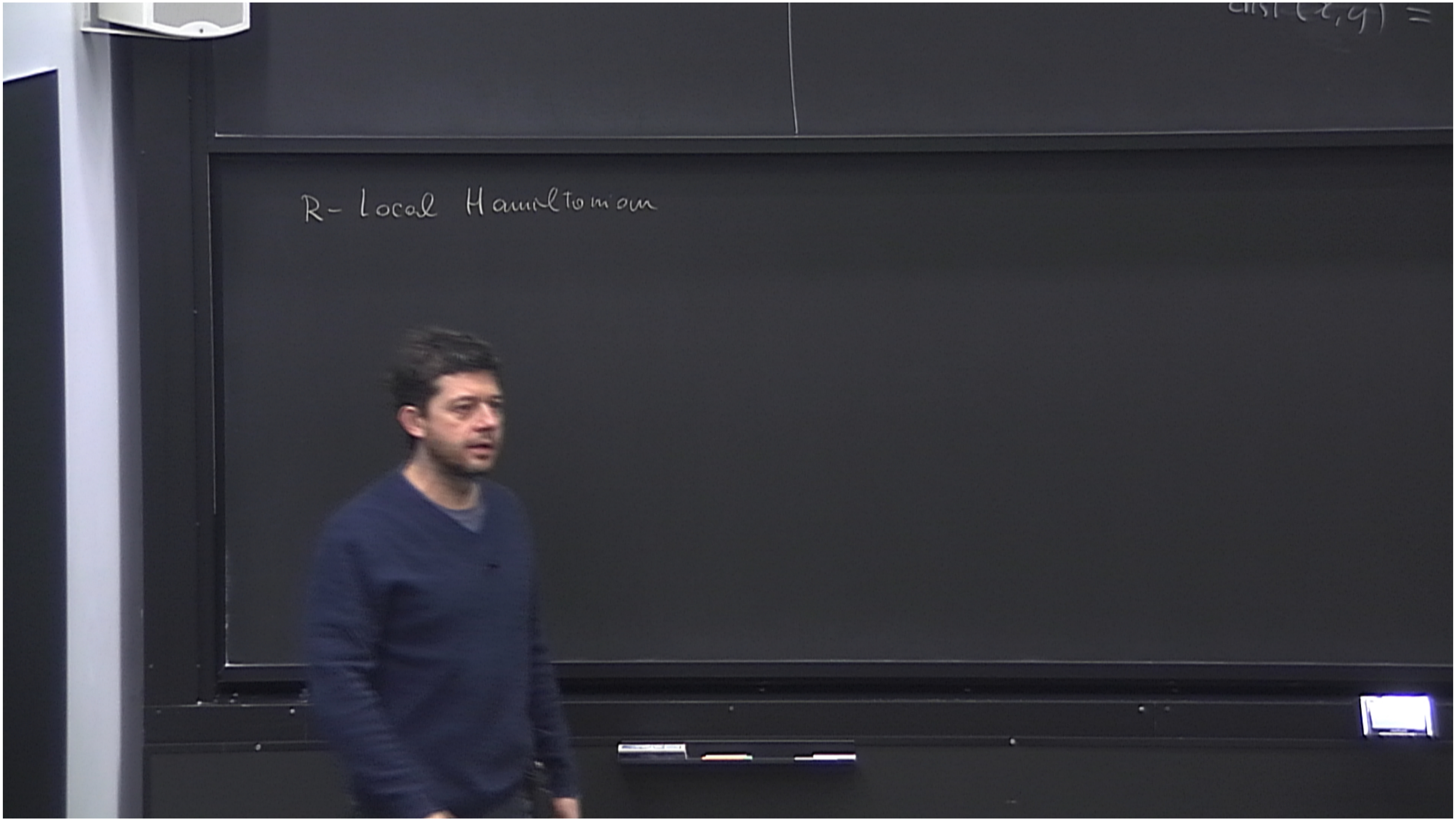

Local Quantum System
(generalized spin system)
H_Λ = ⊗_{x∈Λ} H_x   Total Hilbert space
x∈Λ → H_x local Hilbert space
GSS
dim H_x < ∞
X ⊂ Λ → H_X = ⊗_{x∈X} H_x
Ô ∈ H_Λ   If Ô = Ô_X ⊗ 1_X̄
supp(Ô) = H_X
Λ = X ∪ X̄
d(x,y)   x,y ∈ X
x,y ∈ path

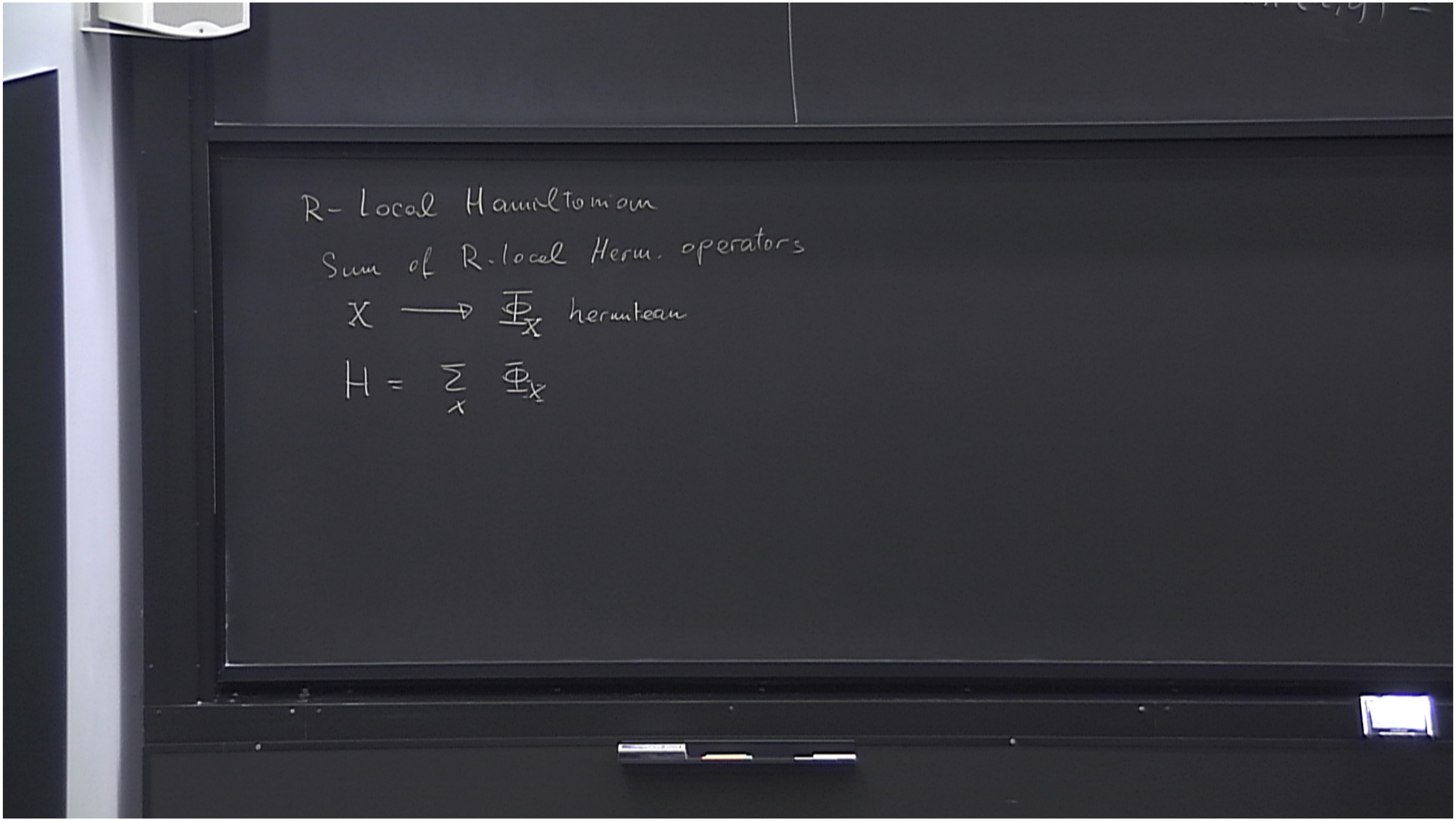

Local Quantum System
(generalized spin system)
H_Λ = ⊗_{x∈Λ} H_x Total Hilbert space
GSS
dim H_x < ∞
x ∈ Λ → H_x local Hilbert space
X ⊂ Λ → H_X = ⊗_{x∈X} H_x
Ô ∈ H_Λ If Ô = Ô_X ⊗ 1_X̄
supp(Ô) = H_X
Λ = X ∪ X̄
X = |X|
X = max d(x,y) x,y ∈ X
e_l ∩ e_{l+1} ≠ φ
x, y ∈ path
L(path(x,y))

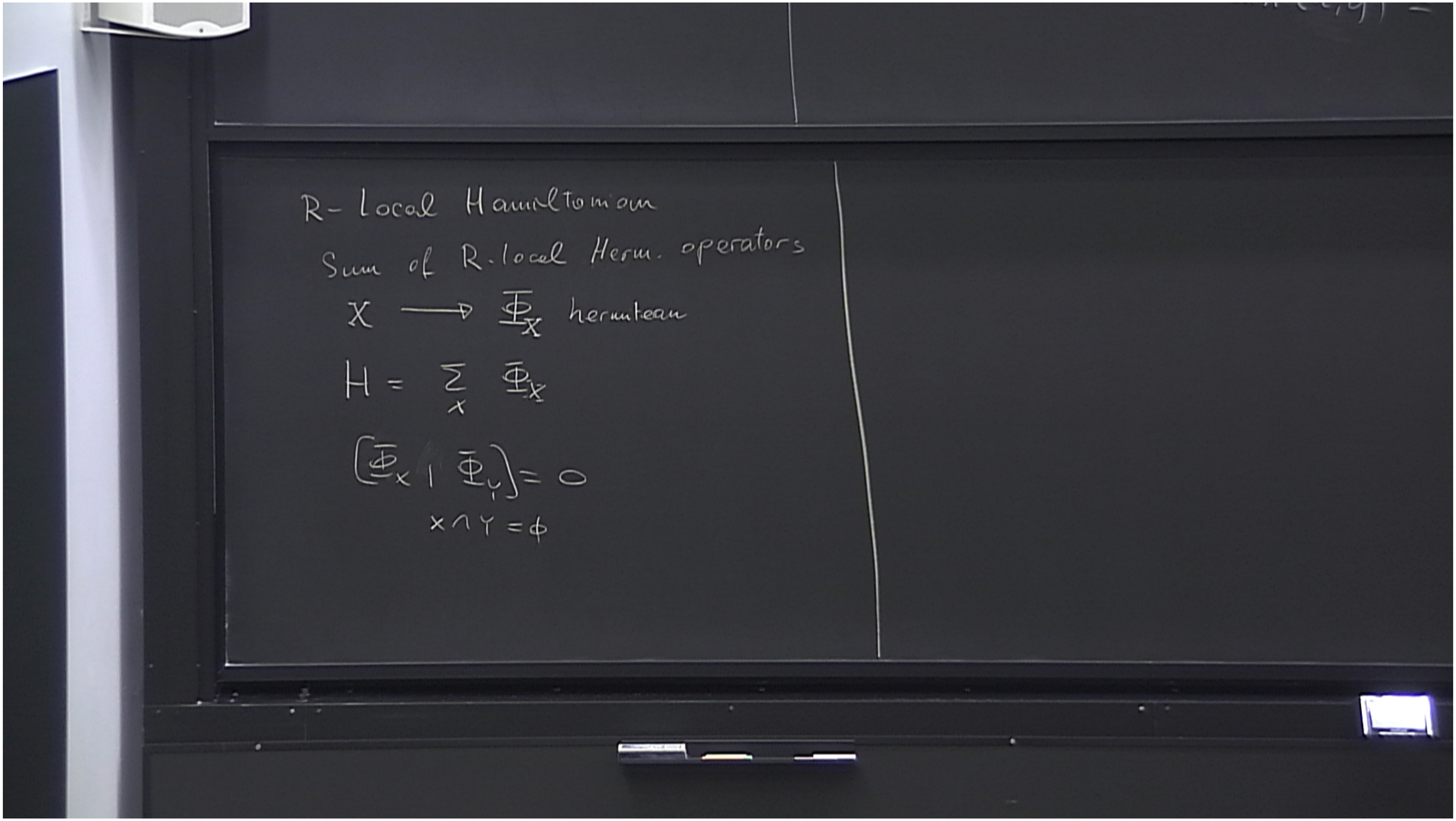

Local Quantum System
(generalized spin system)
Total Hilbert space
x ∈ Λ → H_x local Hilbert space
dim H_x < ∞
X ⊂ Λ → H_X = ⊗_{x∈X} H_x
Ô ∈ H_Λ If Ô = Ô_X ⊗ 1_X̄ Supp(Ô) = H_X
Λ = X ∪ X̄ R-local if diam Supp(Ô) < R
d(x, y) x, y ∈ X
x, y ∈ path
L(path(x, y))

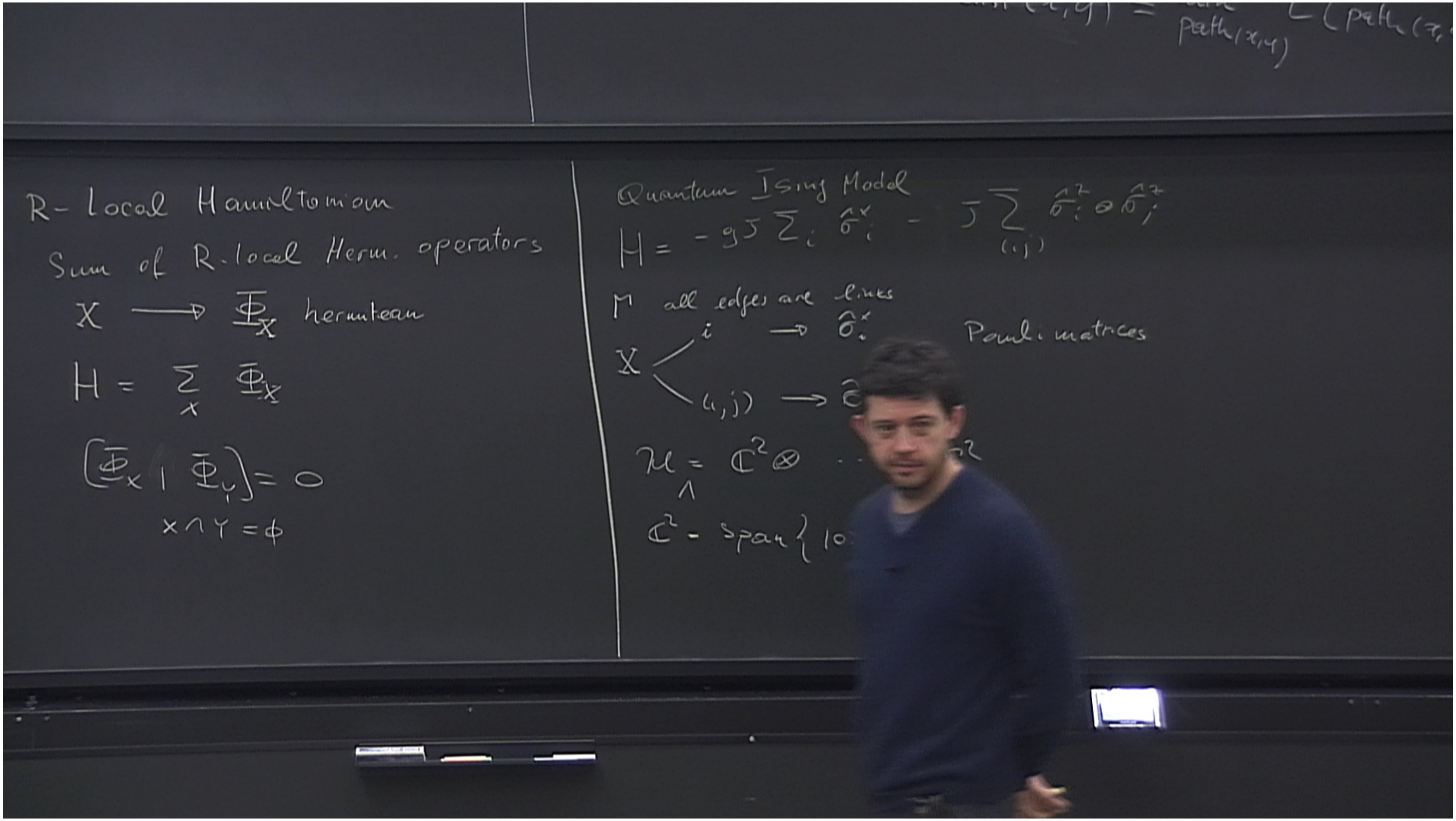


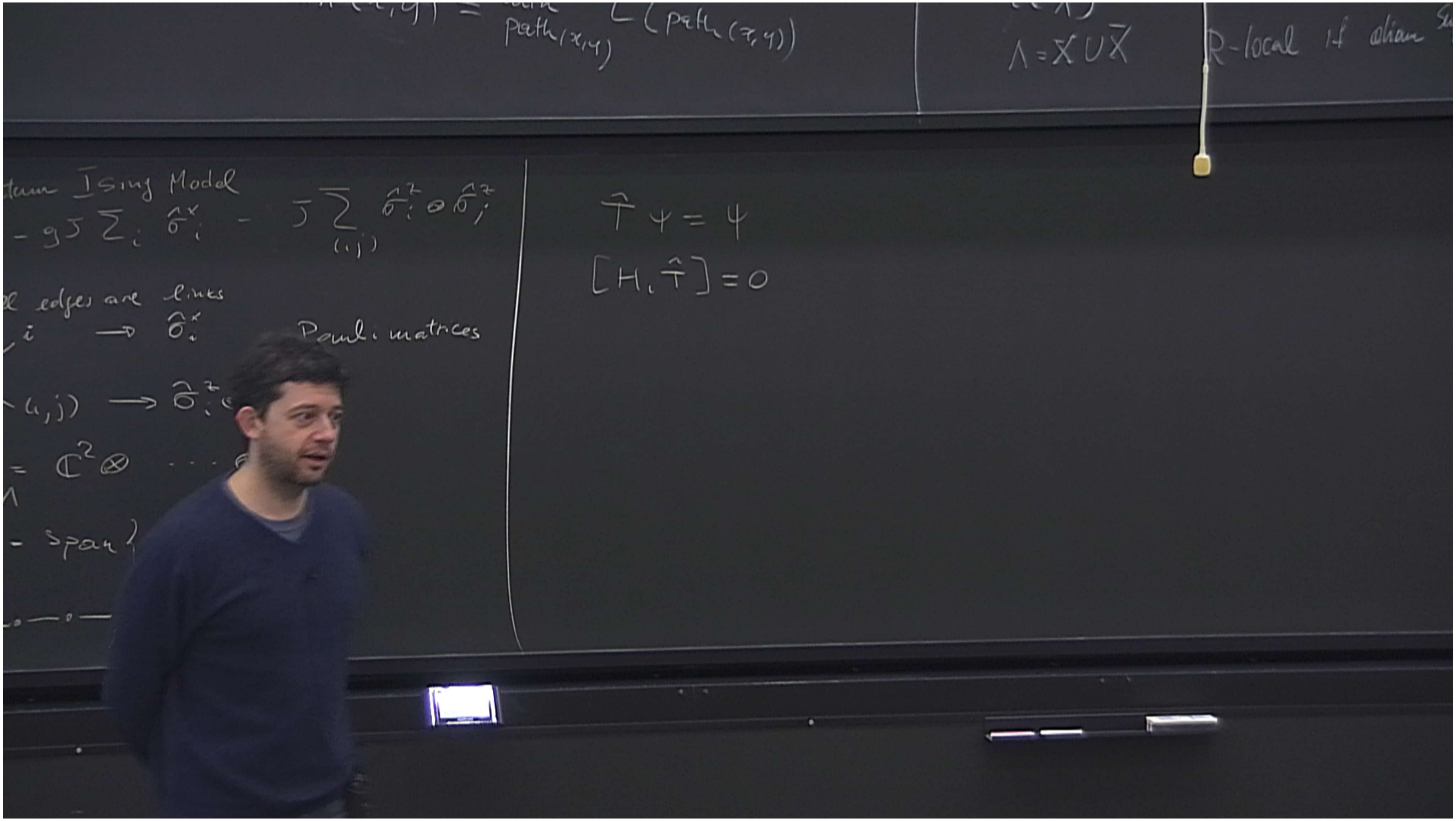
H(λ¹, λ²)
+ H′(λ¹, λ², λ³)
P₁
P₂
Γ = (Λ, E)
set
set of "edges"
E ⊂ 𝒫(Λ)
deg(x) = |{ e∈E | x∈e }|
path(x,y) =
dist(x,y) = min path(x,y) L(pa
X ⊂ Λ
vol X = |X|
diam X = max x,y

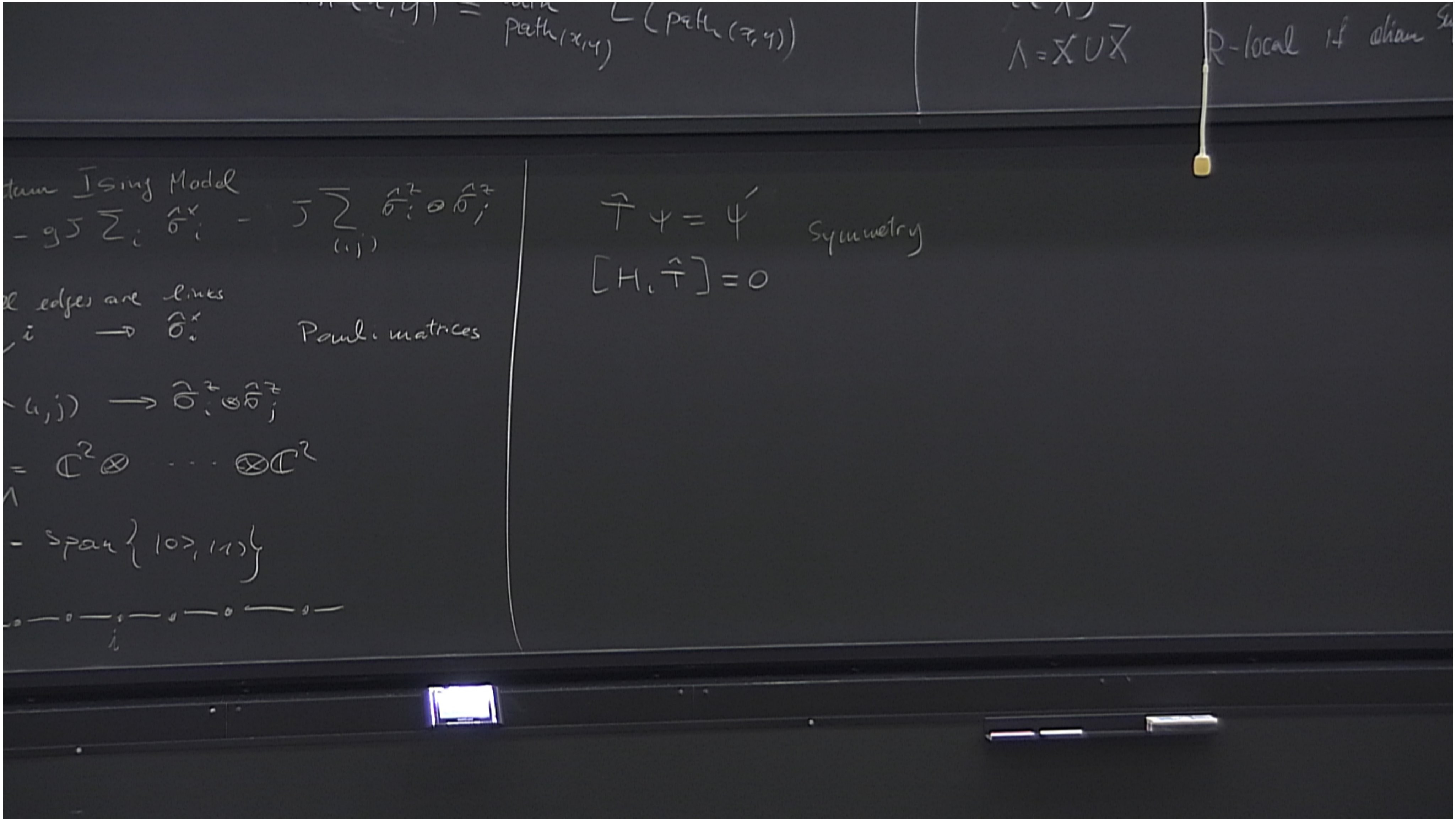

R- Local Hamiltonian


R- Local Hamiltonian
Sum of R-local Herm. operators
$X \longrightarrow \Phi_X$ hermitean
$H = \sum_X \Phi_X$

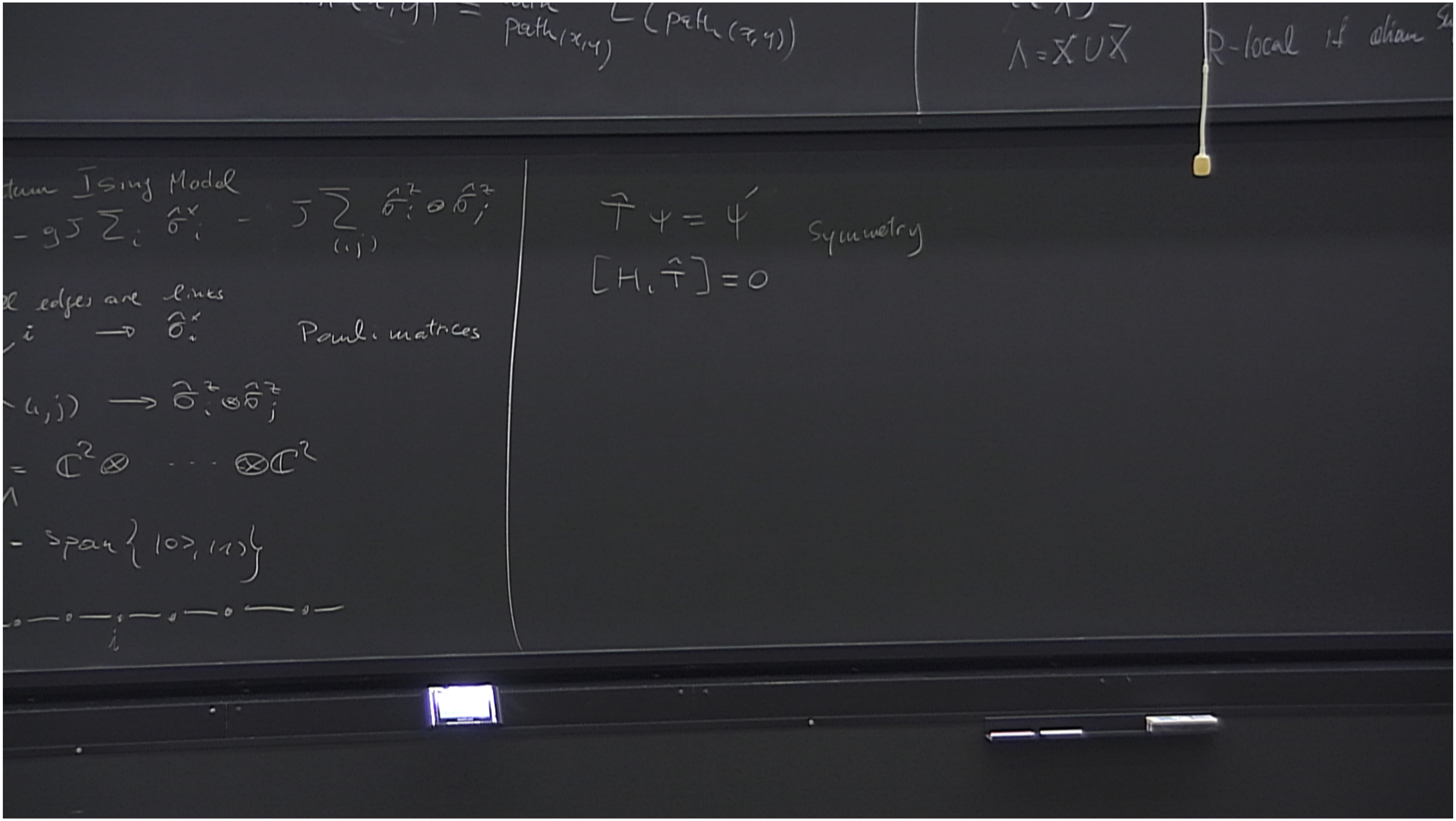

R- Local Hamiltonian
Sum of R-local Herm. operators
X ⟶ Φ_X hermitean
H = Σ_X Φ_X
[Φ_X , Φ_Y] = 0
X ∩ Y = ϕ

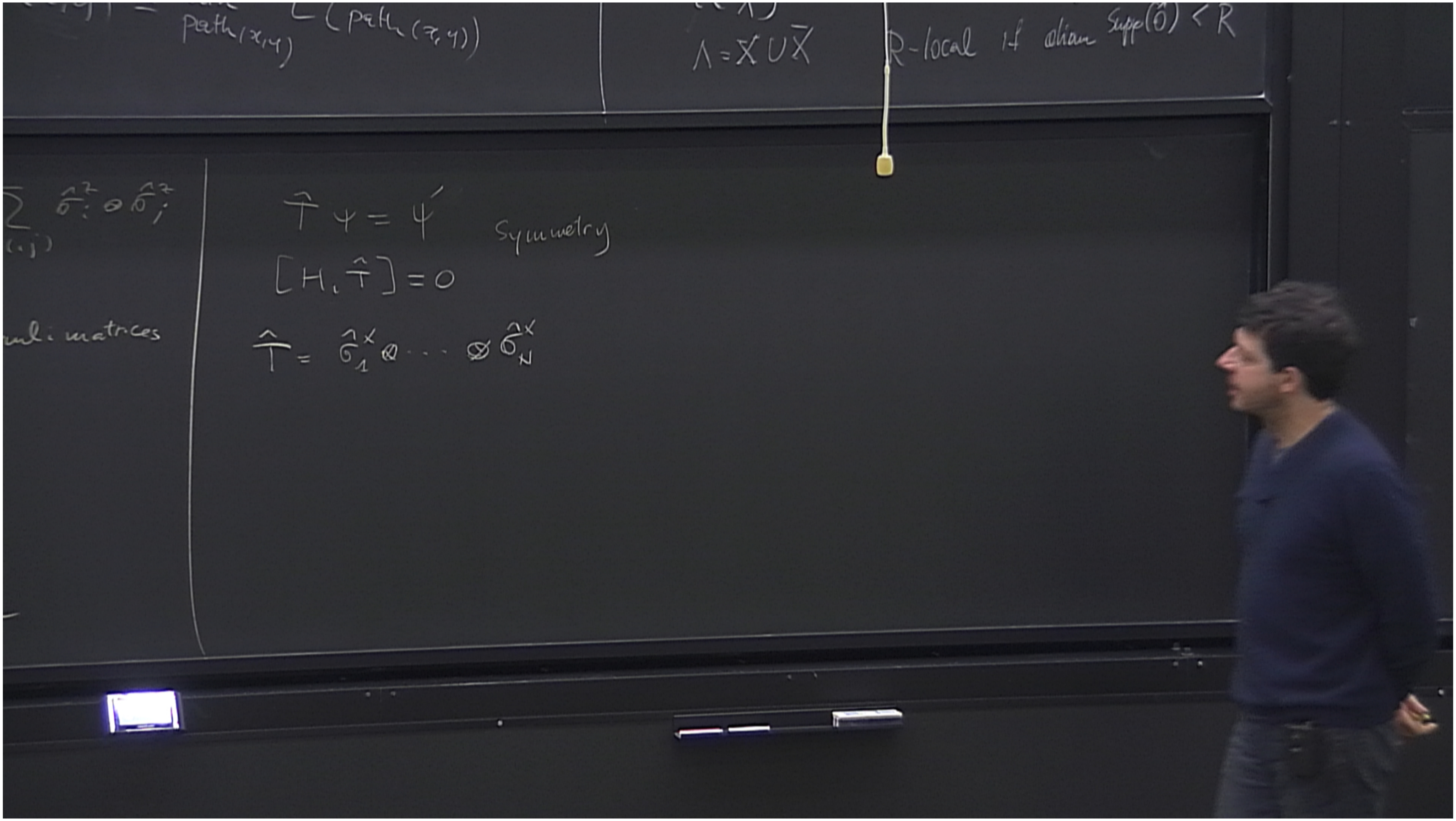

R- Local Hamiltonian
Sum of R-local Herm. operators
X ⟶ Φ_X hermitean
H = Σ_X Φ_X
[Φ_X , Φ_Y] = 0
X ∩ Y = ϕ
Quantum Ising Model
all edges are lines
Pauli matrices

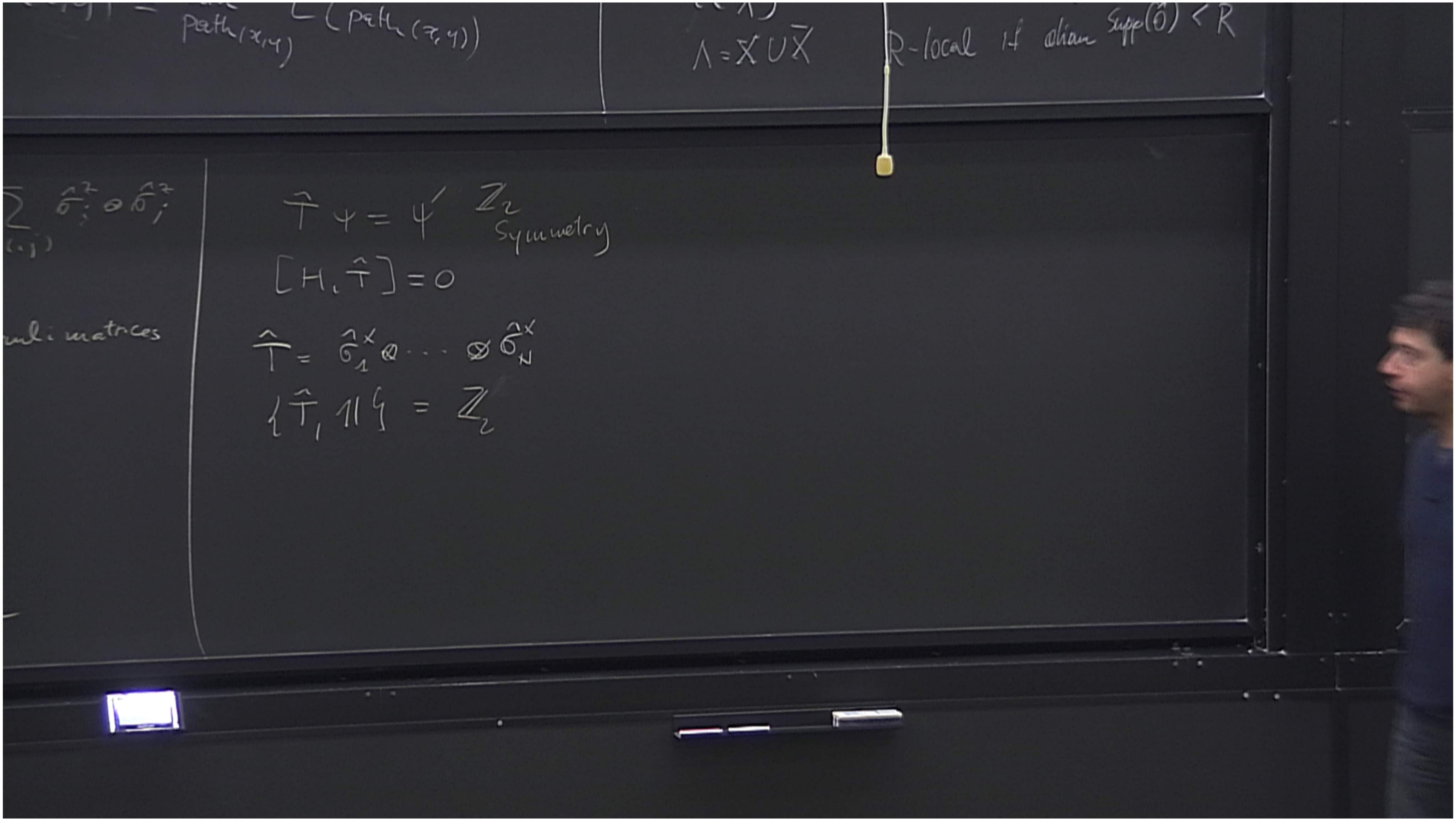

path(x,y)
Λ = X ∪ X̄
R-local if
Ising Model
edges are links
Pauli matrices
T̂ ψ = ψ
[H, T̂] = 0
span

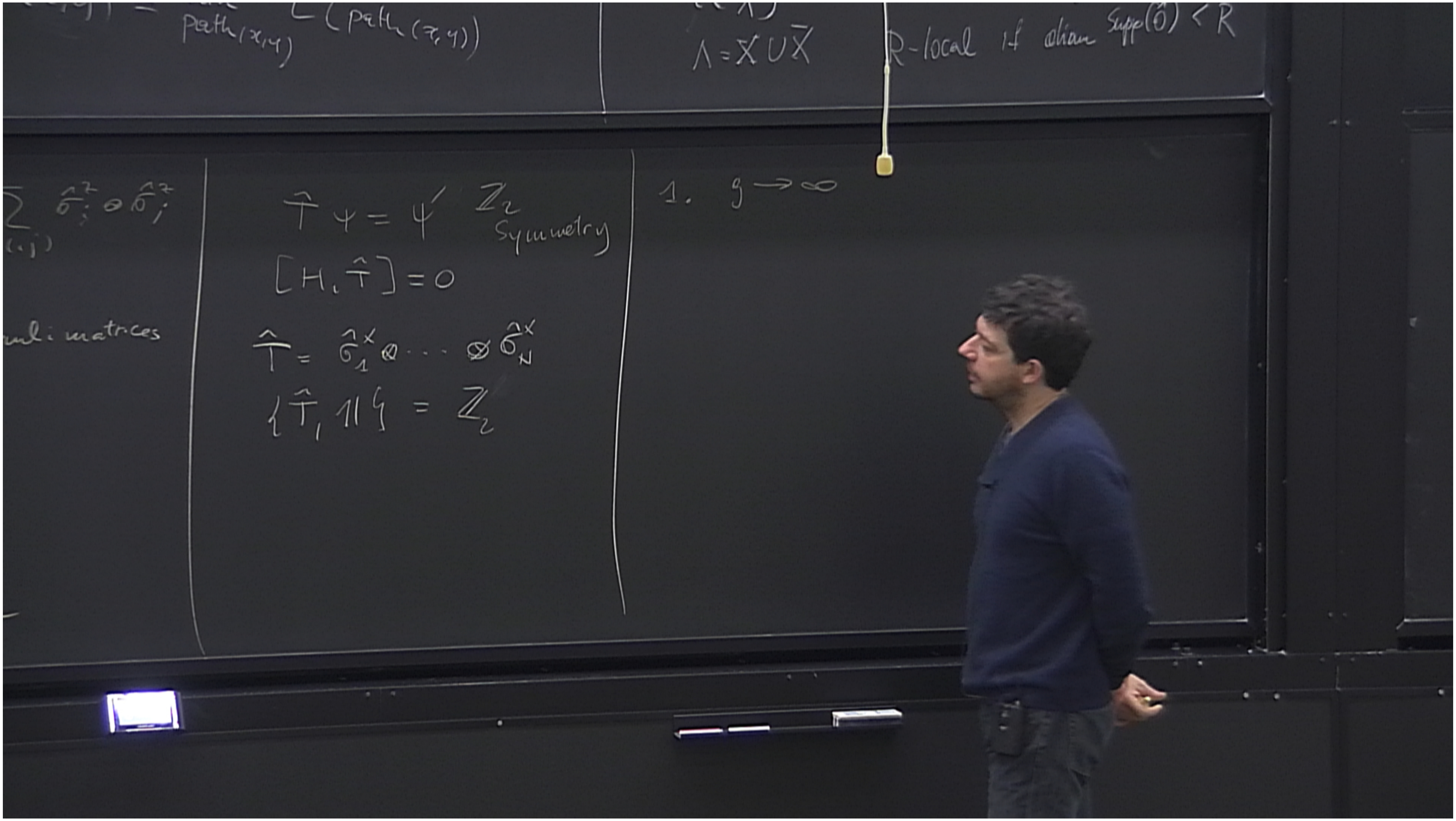


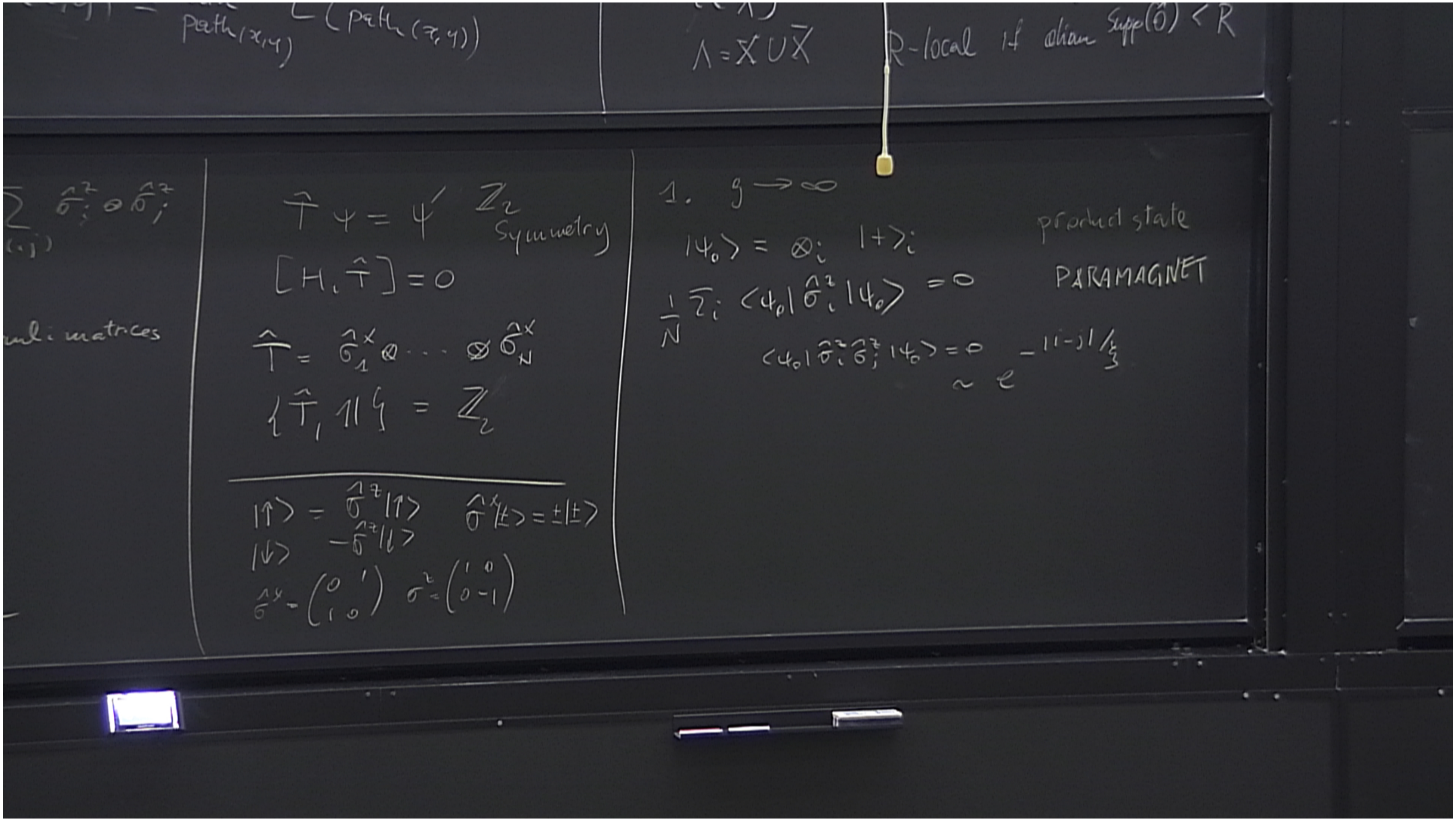
R-local if diam
Ising Model
edges are links
Pauli matrices
$\hat{T}\psi = \psi'$
Symmetry
$[H, \hat{T}] = 0$

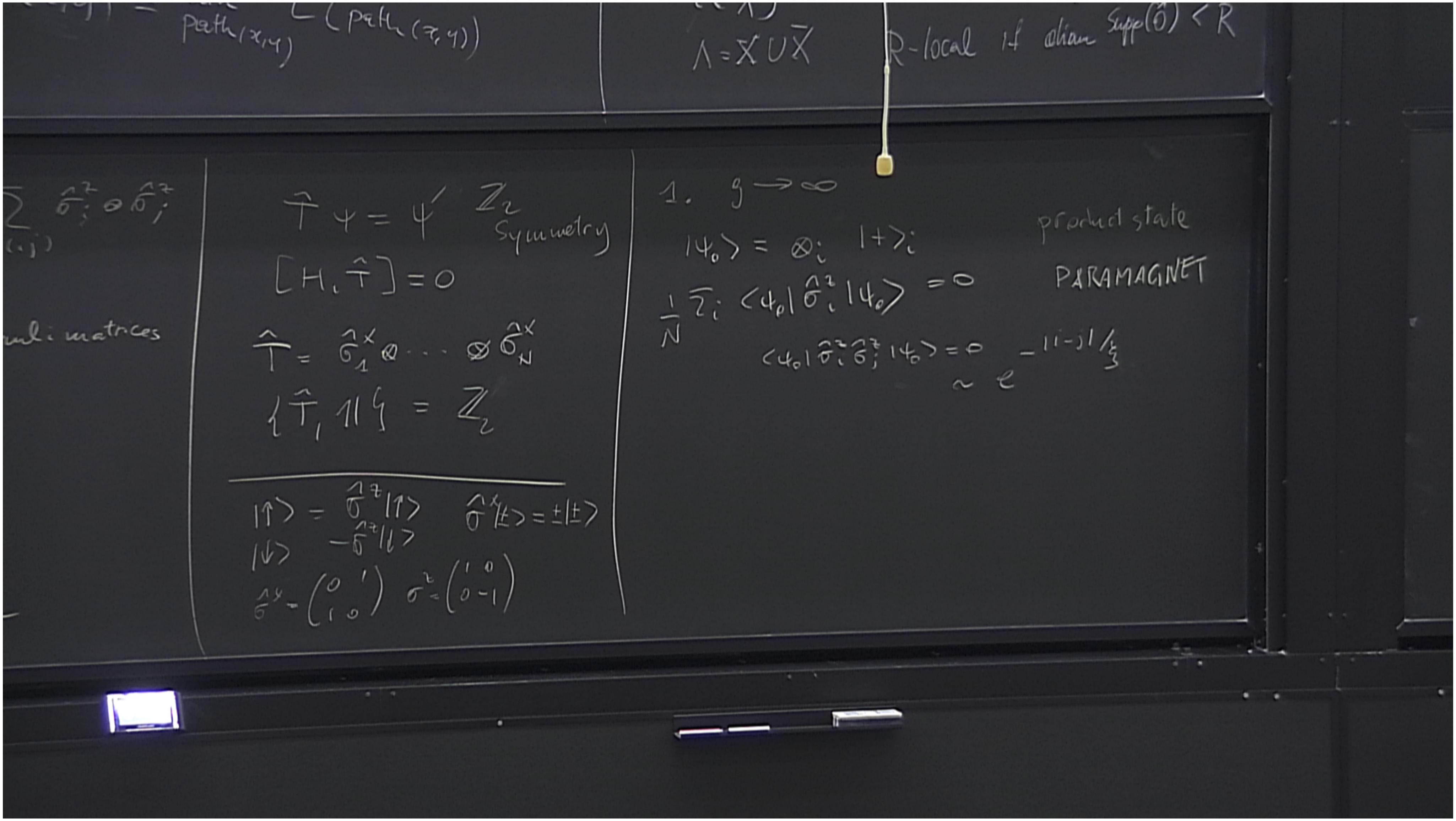

path(x,y)
L(path(x,y))
Λ = X ∪ X̄
R-local if diam
Ising Model
T̂ψ = ψ′ Symmetry
[H, T̂] = 0
edges are links
Pauli matrices
span{|0>, |1>}

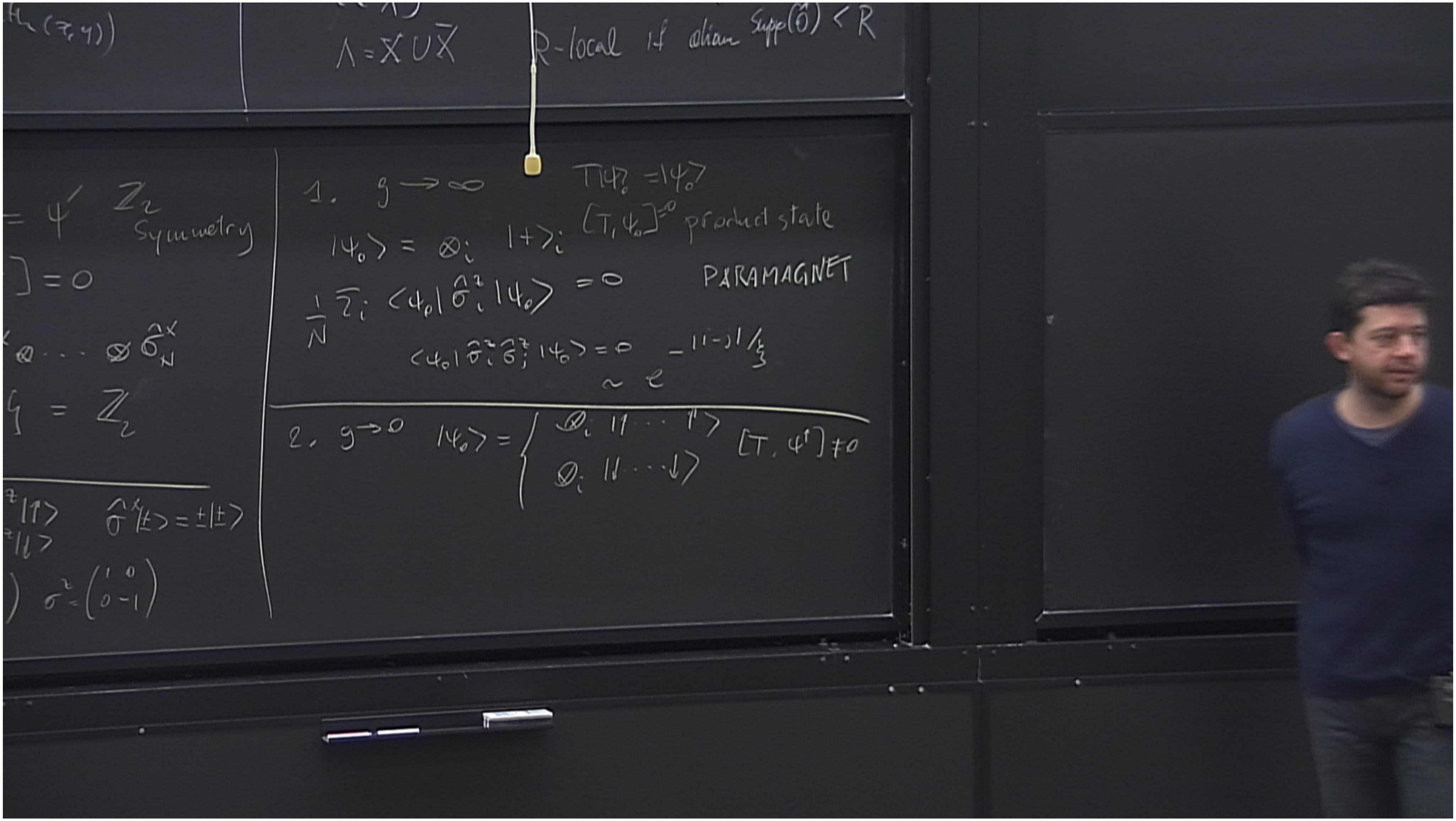

path(x,y) L(path(x,y))
Λ = X ∪ X̄
R-local if diam Supp(σ̂) < R
T̂ ψ = ψ'
Symmetry
[H, T̂] = 0
T̂ = σ̂₁ˣ ⊗ · · · ⊗ σ̂ₙˣ
matrices

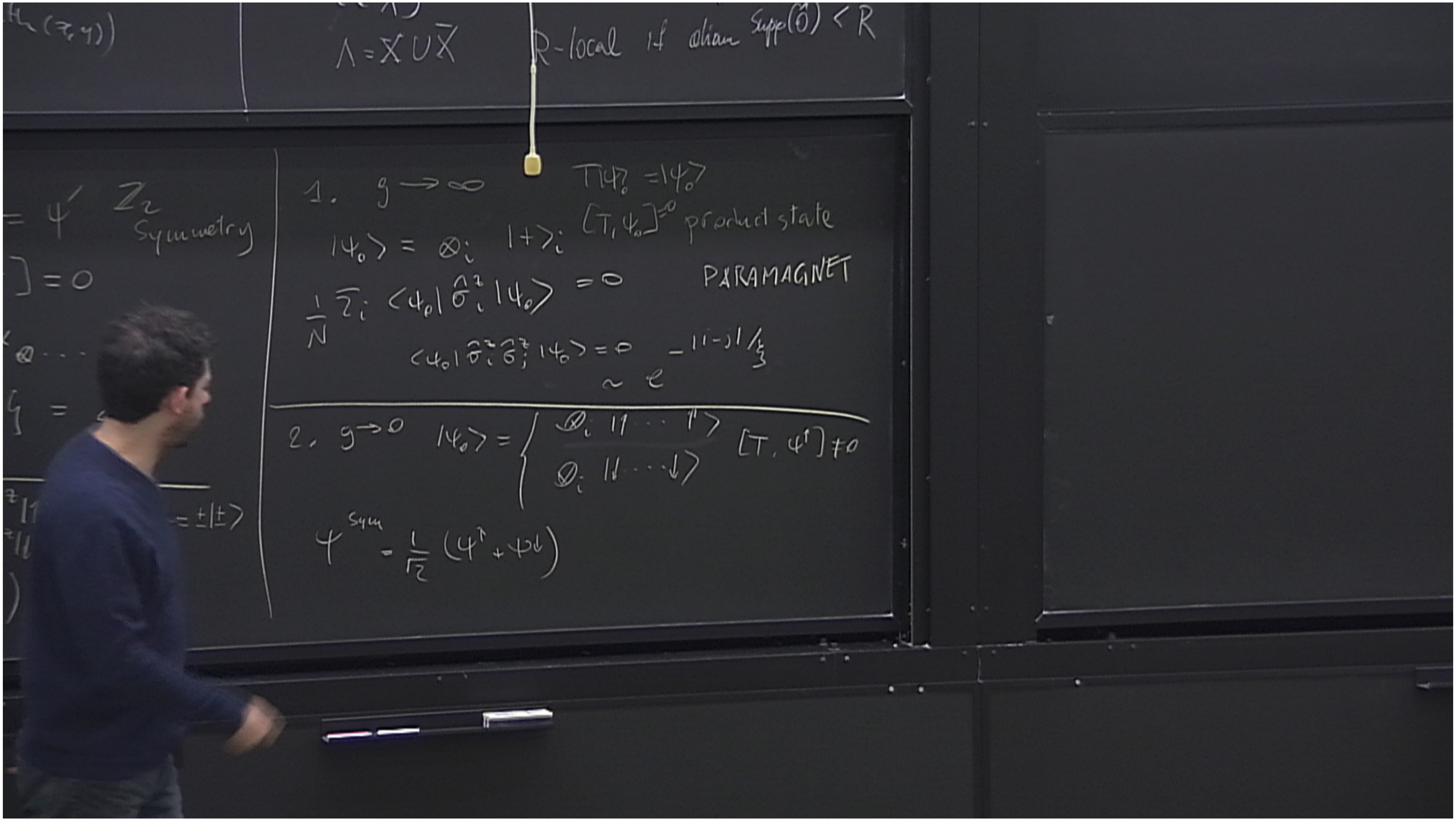

Λ = X ∪ X̄
R-local if diam Supp(Ô) < R
T̂ ψ = ψ′ Z2 Symmetry
[H, T̂] = 0
T̂ = σ̂1x ⊗ · · · ⊗ σ̂Nx
{T̂, 1} = Z2

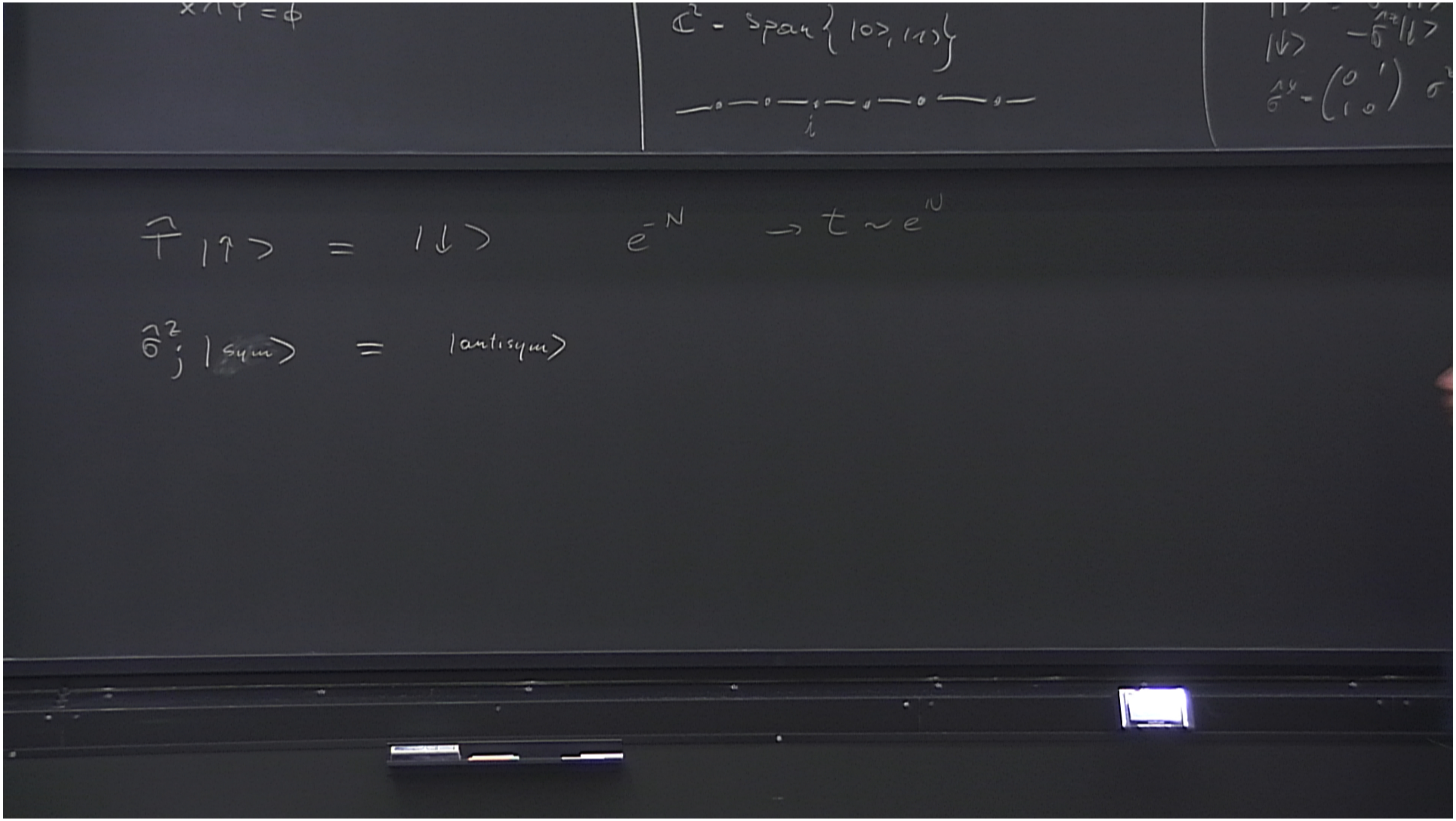

R-local if diam Supp(Ô) < R
Λ = X ∪ X̄
T̂ ψ = ψ′ Z2 Symmetry
[H, T̂] = 0
T̂ = σ̂1x ⊗ · · · ⊗ σ̂Nx
{T̂, 1} = Z2
1. g → ∞
matrices


path(x,y) L(path(x,y))
Λ = X ∪ X̄
R-local if diam Supp(Ô) < R
T̂ψ = ψ′ Z2 symmetry
[H, T̂] = 0
T̂ = σ̂1x ⊗ … ⊗ σ̂Nx
{T̂, 1} = Z2
|↑⟩ = σ̂z|↑⟩   σ̂x|±⟩ = ±|±⟩
|↓⟩ −σ̂z|↓⟩
σ̂x = (0 1 / 1 0) σz = (1 0 / 0 −1)
Pauli matrices
1. g → ∞
|ψ0⟩ = ⊗i |+⟩i
product state
PARAMAGNET
1/N Σi ⟨ψ0| σ̂iz |ψ0⟩ = 0
⟨ψ0| σ̂iz σ̂jz |ψ0⟩ = 0
~ e−|i−j|/ξ


path(x,y)
Λ = X ∪ X̄
R-local if diam Supp(Ô) < R
T̂ ψ = ψ′ Z2 Symmetry
[H, T̂] = 0
T̂ = σ̂1x ⊗ · · · ⊗ σ̂Nx
{T̂, 1} = Z2
|↑⟩ = σ̂z|↑⟩ σ̂x|±⟩ = ±|±⟩
|↓⟩ −σ̂z|↓⟩
σ̂x = (0 1 / 1 0) σz = (1 0 / 0 −1)
1. g → ∞
|ψ0⟩ = ⊗i |+⟩i
product state
PARAMAGNET
1/N Σi ⟨ψ0| σ̂iz |ψ0⟩ = 0
⟨ψ0| σ̂iz σ̂jz |ψ0⟩ = 0
~ e−|i−j|/ξ
Pauli matrices


Λ = X ∪ X̄
R-local if diam Supp(Ô) < R
Z2 Symmetry
1. g → ∞
T|ψ0⟩ = |ψ0⟩
[T, ψ0] = 0 product state
|ψ0⟩ = ⊗i |+⟩i
PARAMAGNET
1/N Σi ⟨ψ0| σ̂zi |ψ0⟩ = 0
⟨ψ0| σ̂zi σ̂zj |ψ0⟩ = 0
~ e^(−|i−j|/ξ)
2. g → 0
|ψ0⟩ = ⊗i |↑ ··· ↑⟩
⊗i |↓ ··· ↓⟩
[T, ψ0] ≠ 0
σ̂x |±⟩ = ±|±⟩


Λ = X ∪ X̄
R-local if diam Supp(Ô) < R
Z2 Symmetry
1. g → ∞
T|Ψ0⟩ = |Ψ0⟩
[T, Ψ0] = 0 product state
|Ψ0⟩ = ⊗i |+⟩i
PARAMAGNET
1/N Σi ⟨Ψ0| σ̂ᶻi |Ψ0⟩ = 0
⟨Ψ0| σ̂ᶻi σ̂ᶻj |Ψ0⟩ = 0 ~ e^(−|i−j|/ξ)
2. g → 0
|Ψ0⟩ = ⊗i |↑↑ ··· ↑⟩, ⊗i |↓↓ ··· ↓⟩
[T, Ψ↑] ≠ 0
Ψ^sym = 1/√2 (Ψ↑ + Ψ↓)


x ∩ Y = ϕ
ℂ² = span{|0>, |1>}
i
|↓>
T̂ |↑> = |↓>
e^-N
→ t ~ e^N
σ̂ᶻⱼ |sym> = |antisym>