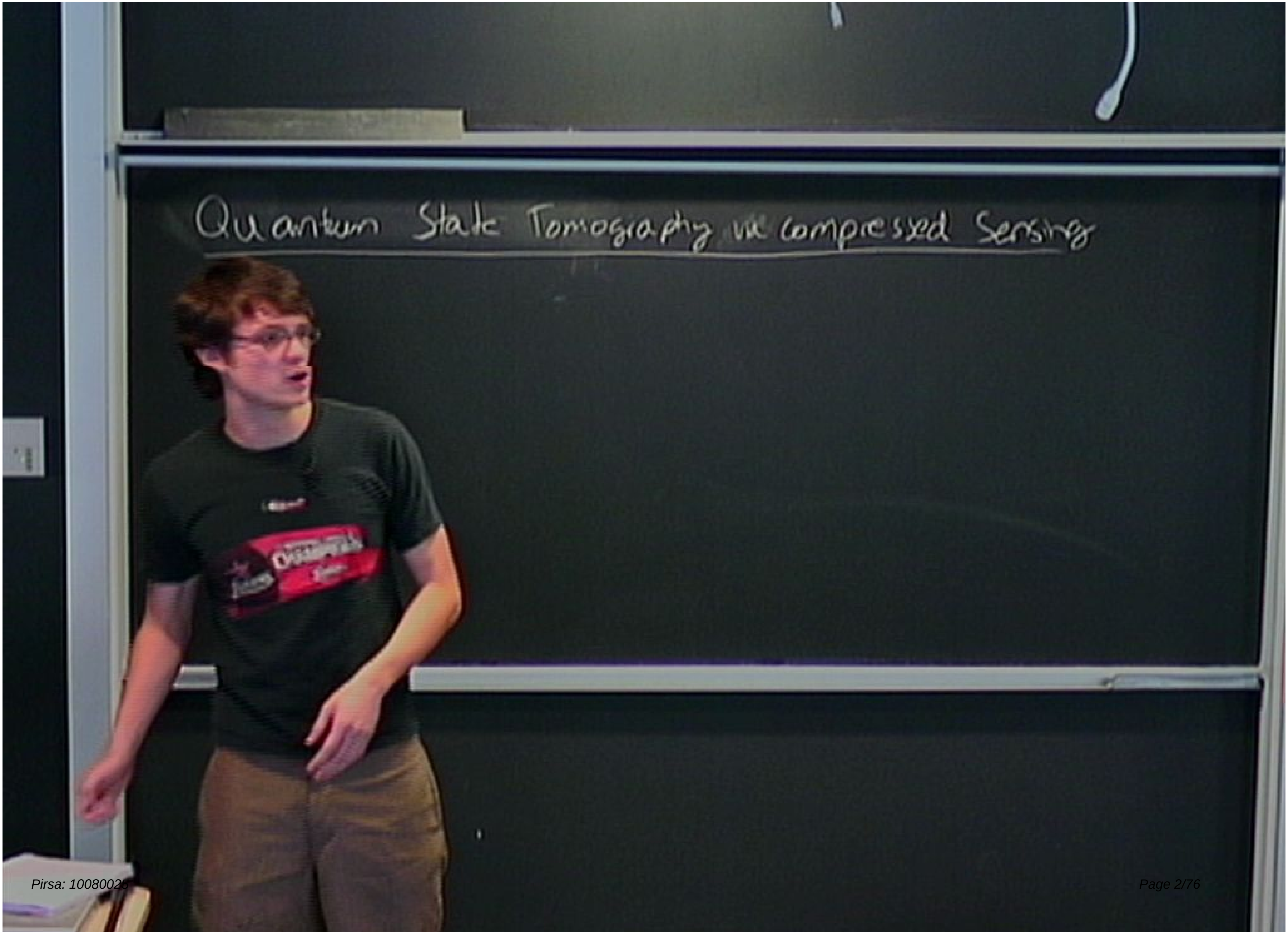
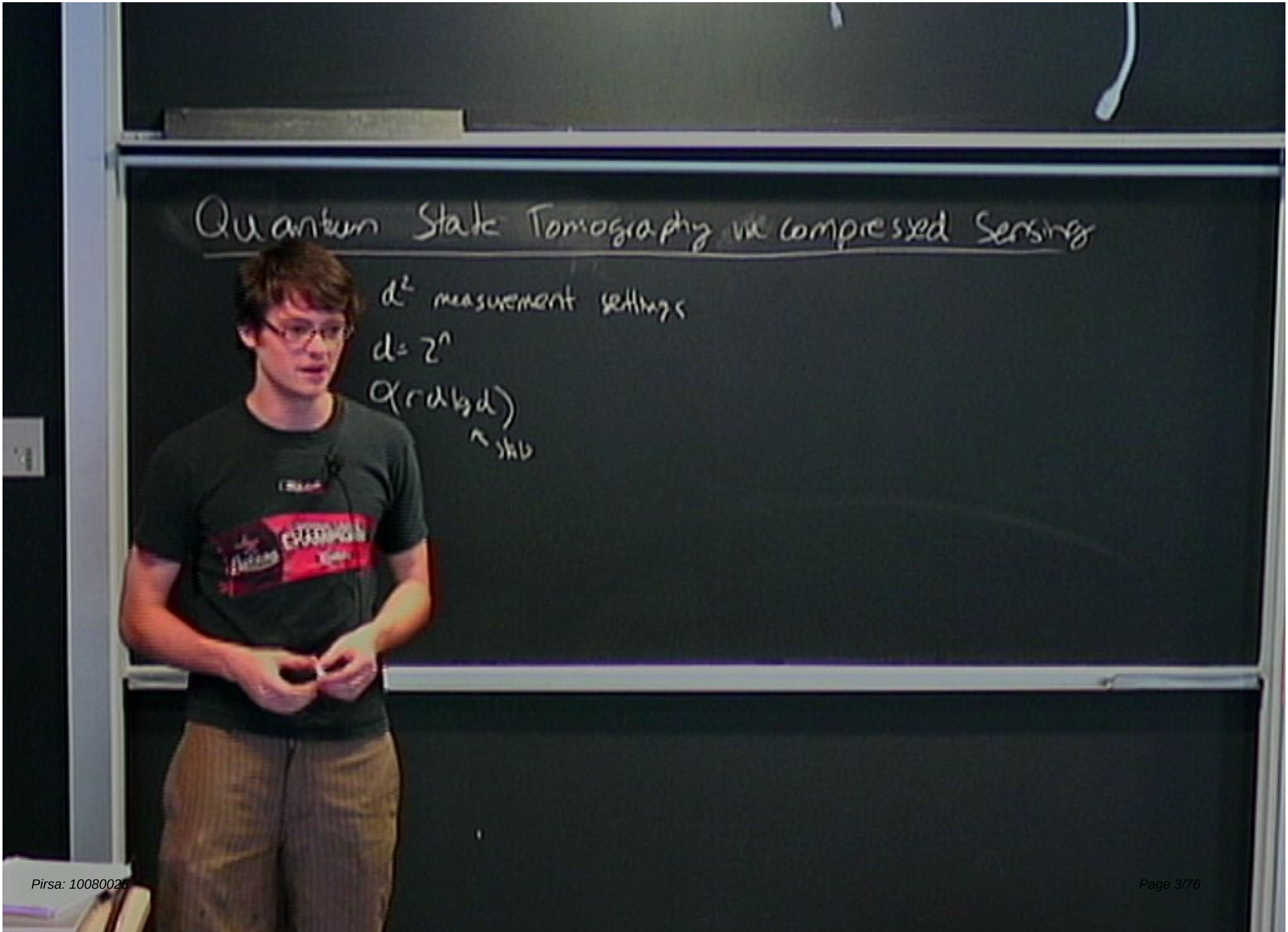
Title: Undergraduate Talk

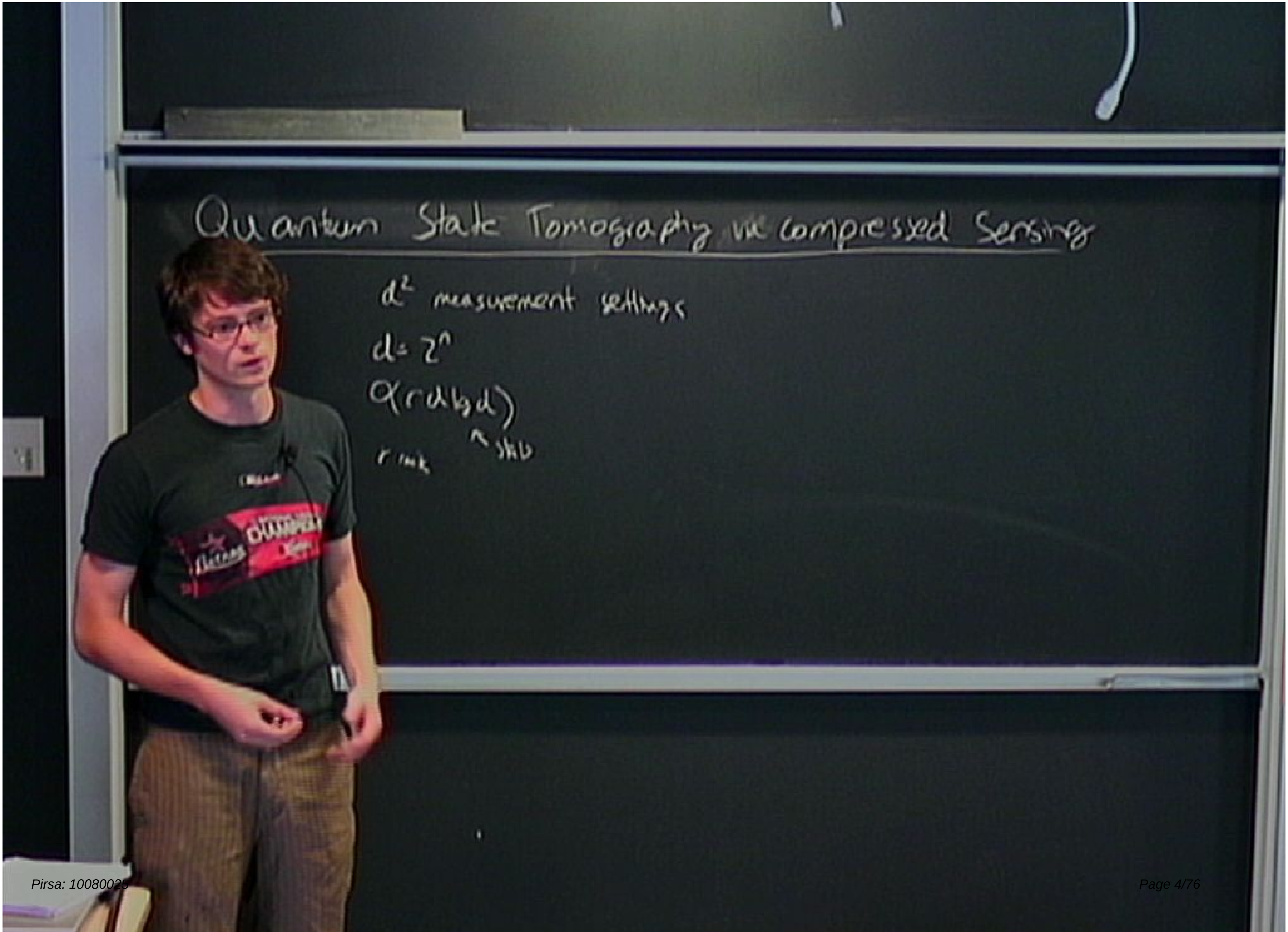
Date: Aug 12, 2010 02:00 PM

URL: http://pirsa.org/10080025

Abstract:


Quantum State Tomography via Compressed Sensing


Quantum State Tomography via compressed Sensing
d² measurement settings
d = 2ⁿ
O(r d log d)


Quantum State Tomography via compressed Sensing
d² measurement settings
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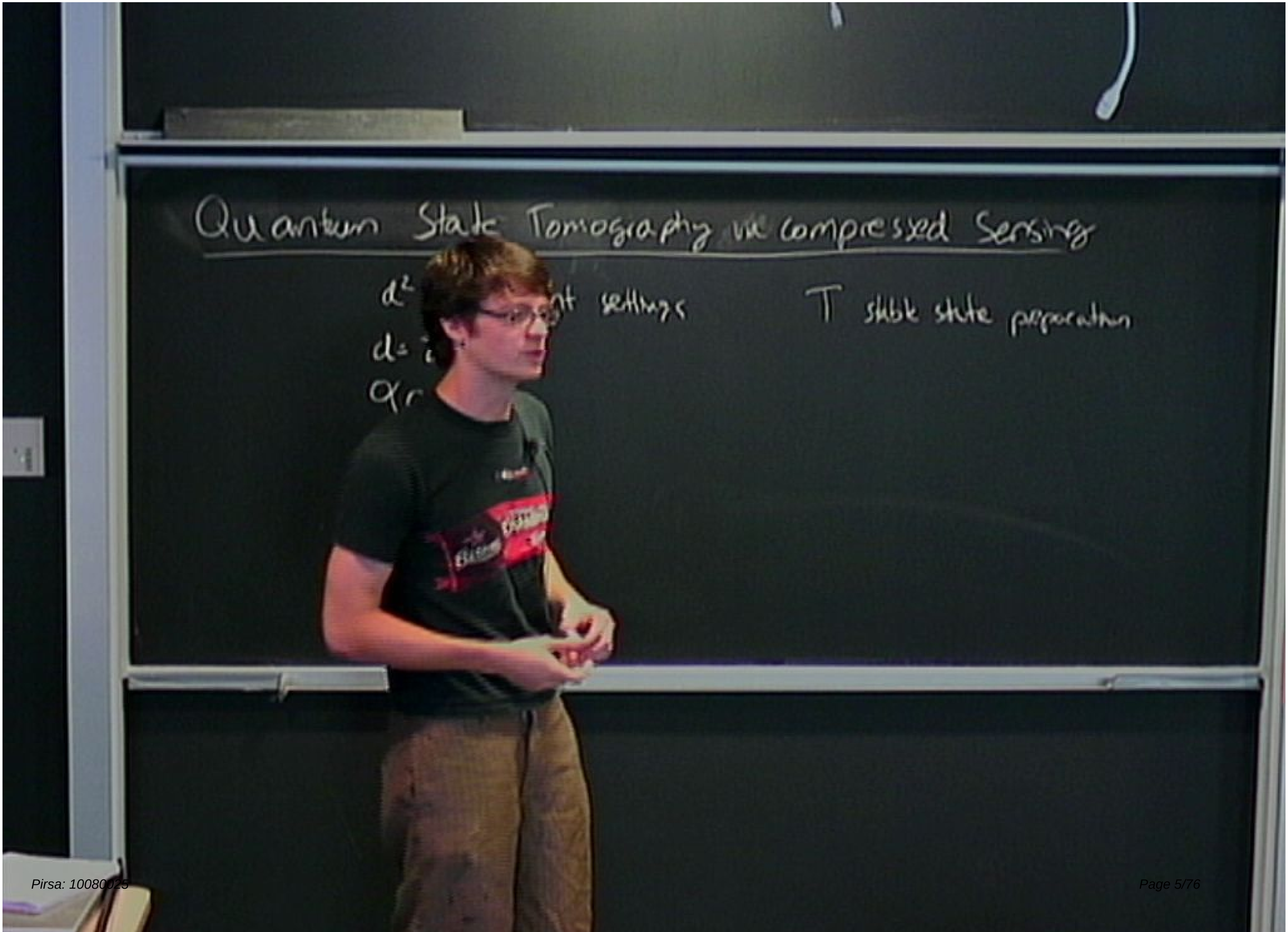
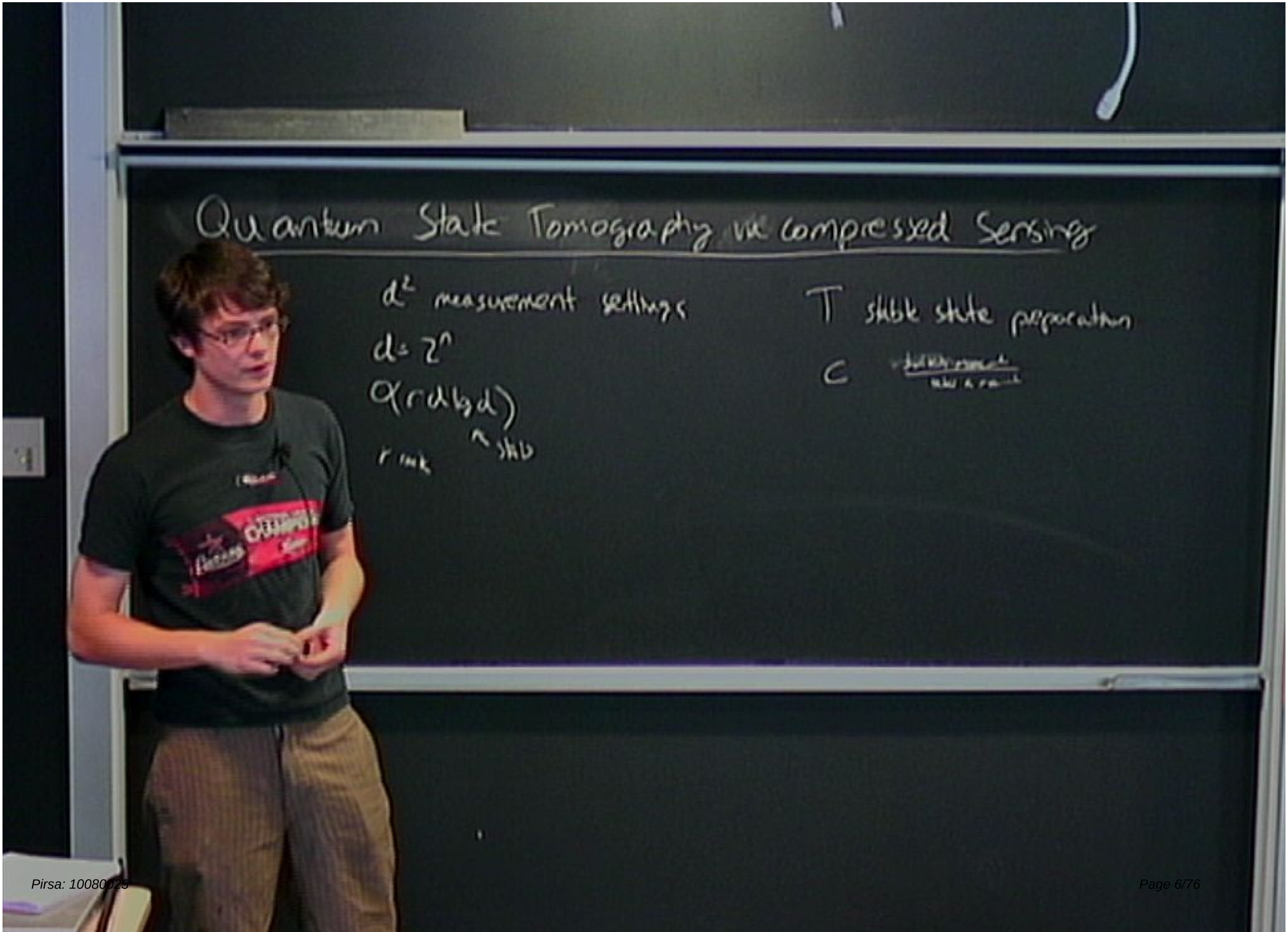
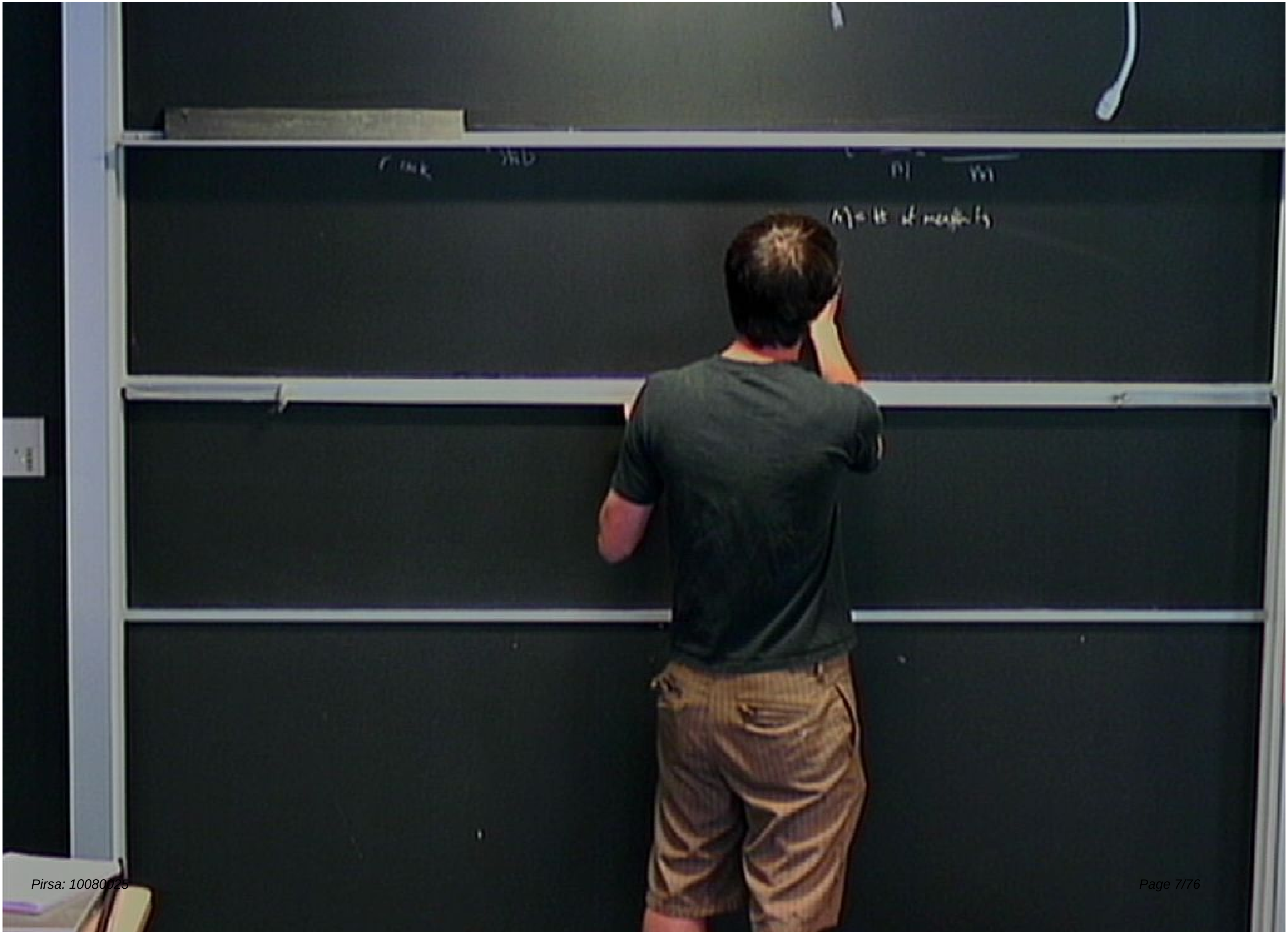
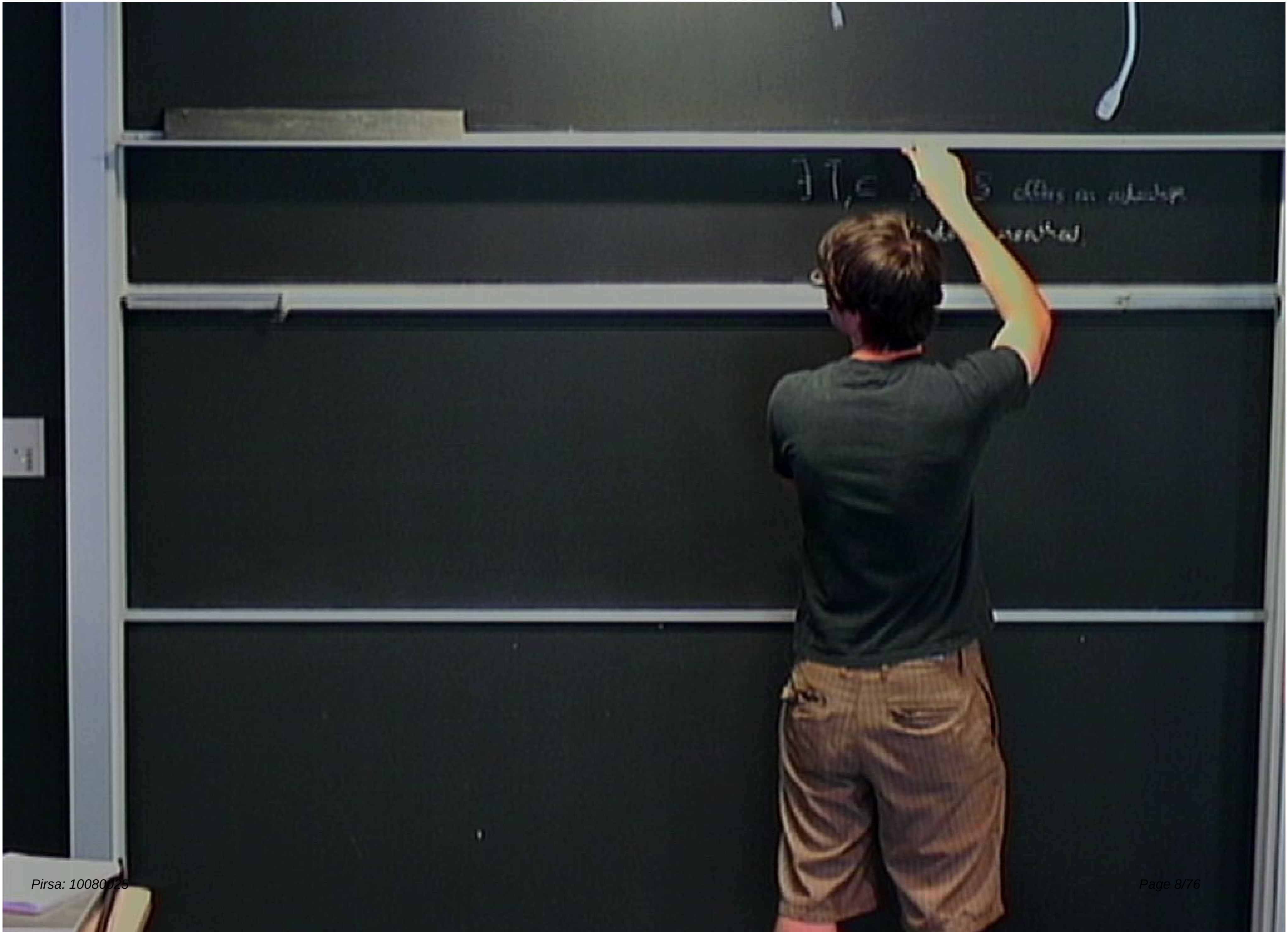
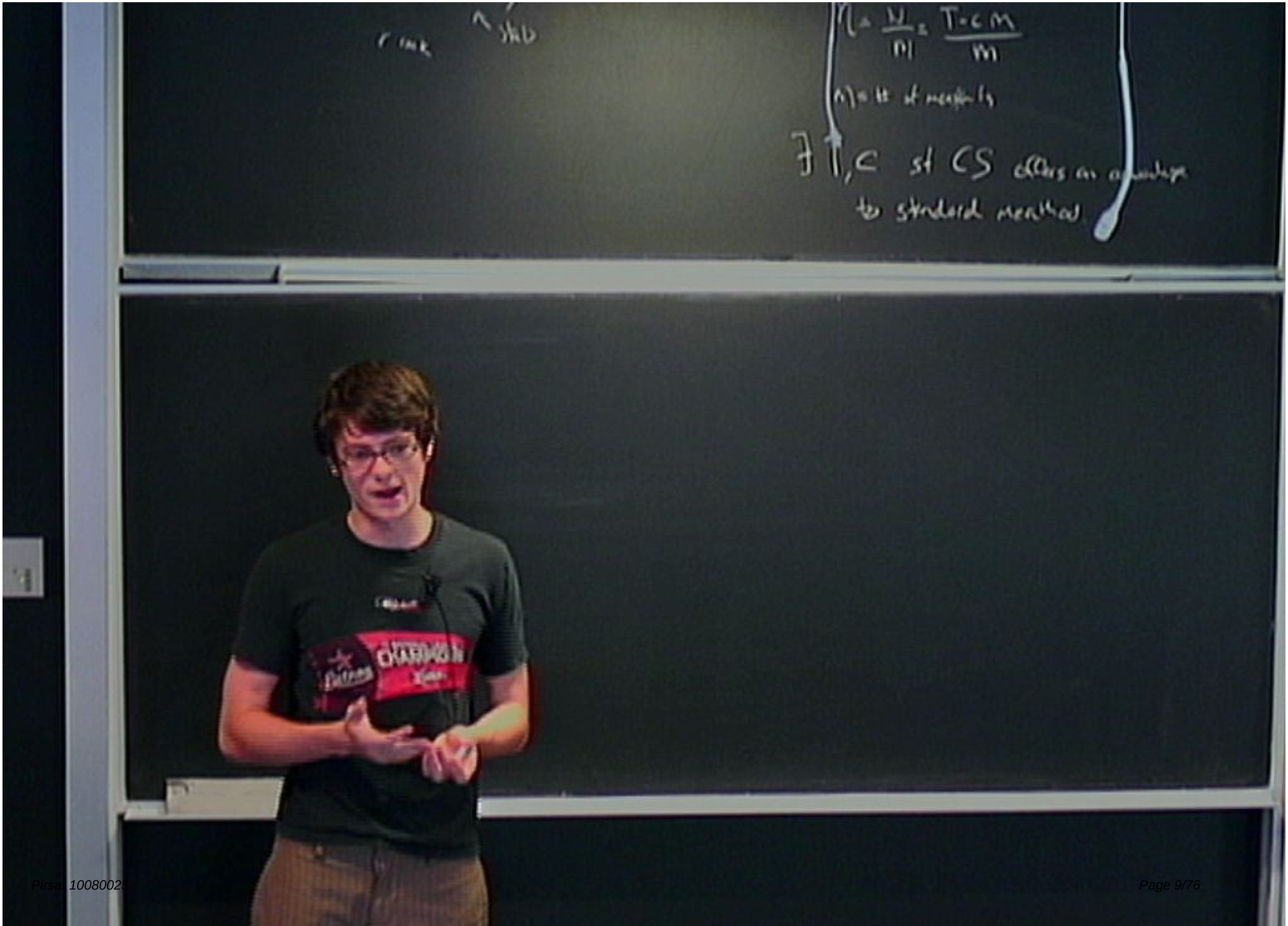
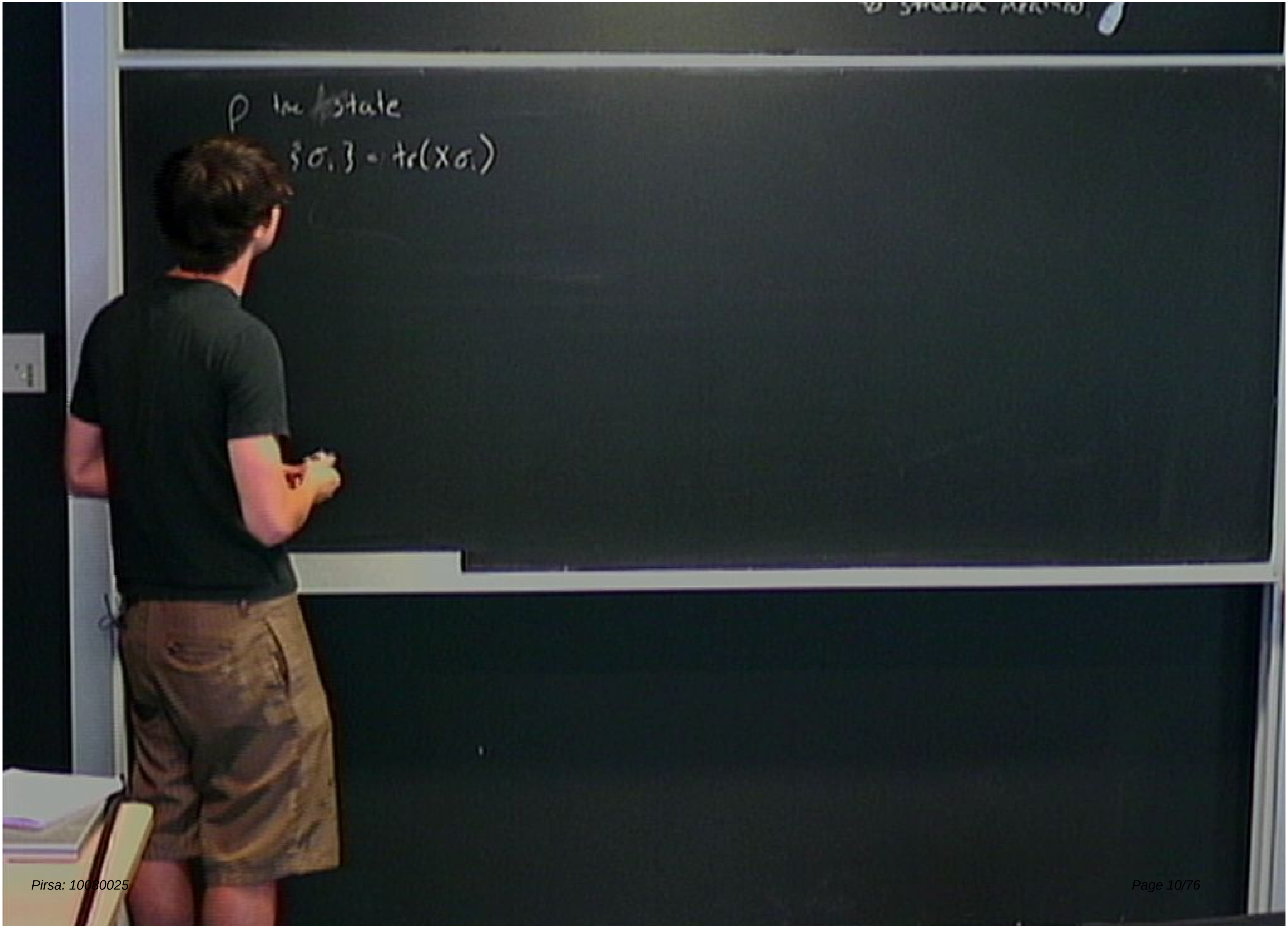

Quantum State Tomography via compressed Sensing
settings
T stable state preparation

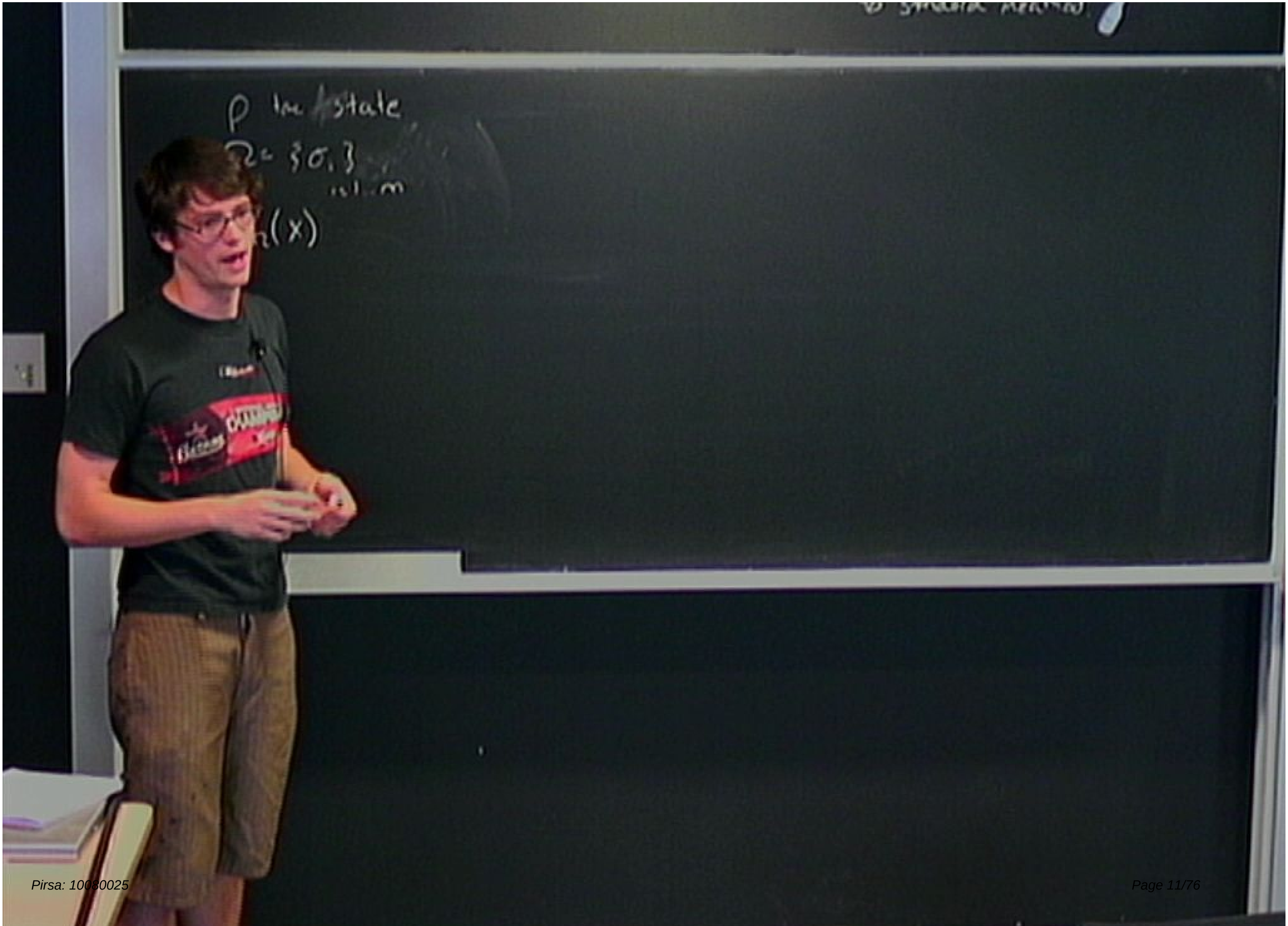

Quantum State Tomography via compressed Sensing
d² measurement settings
d = 2^n
O(r d log d)
r rank
stab
T stable state preparation
C

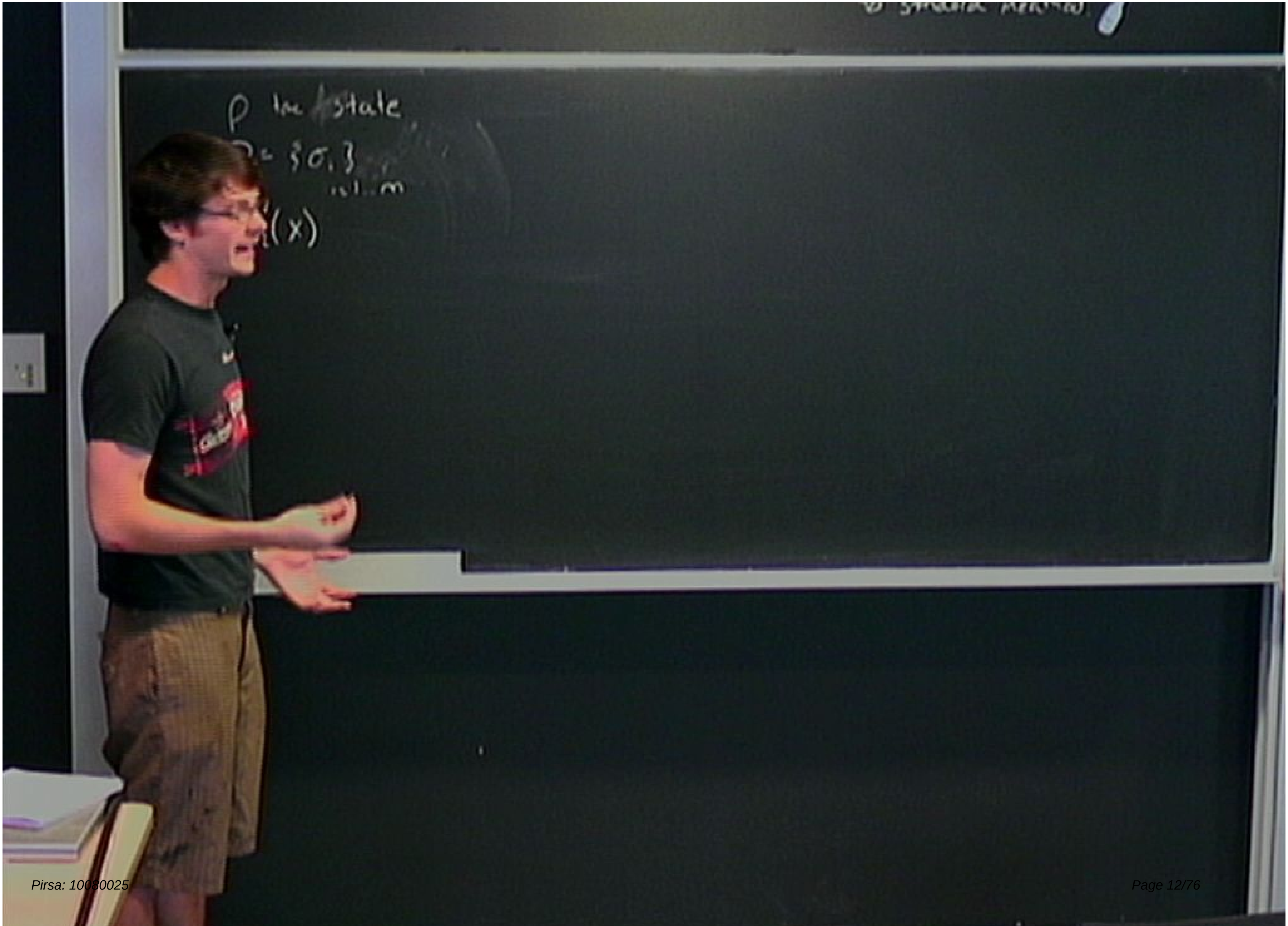


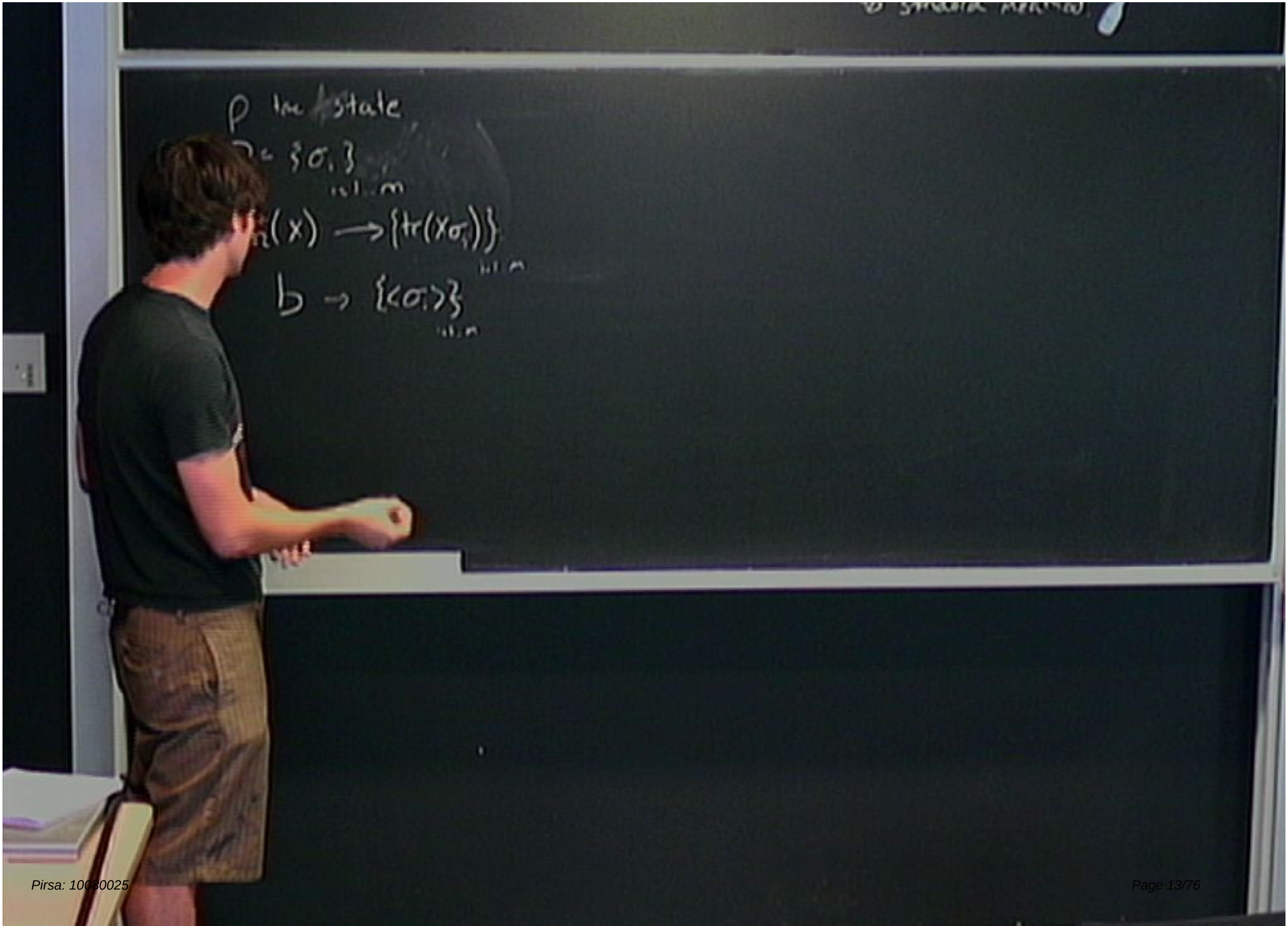


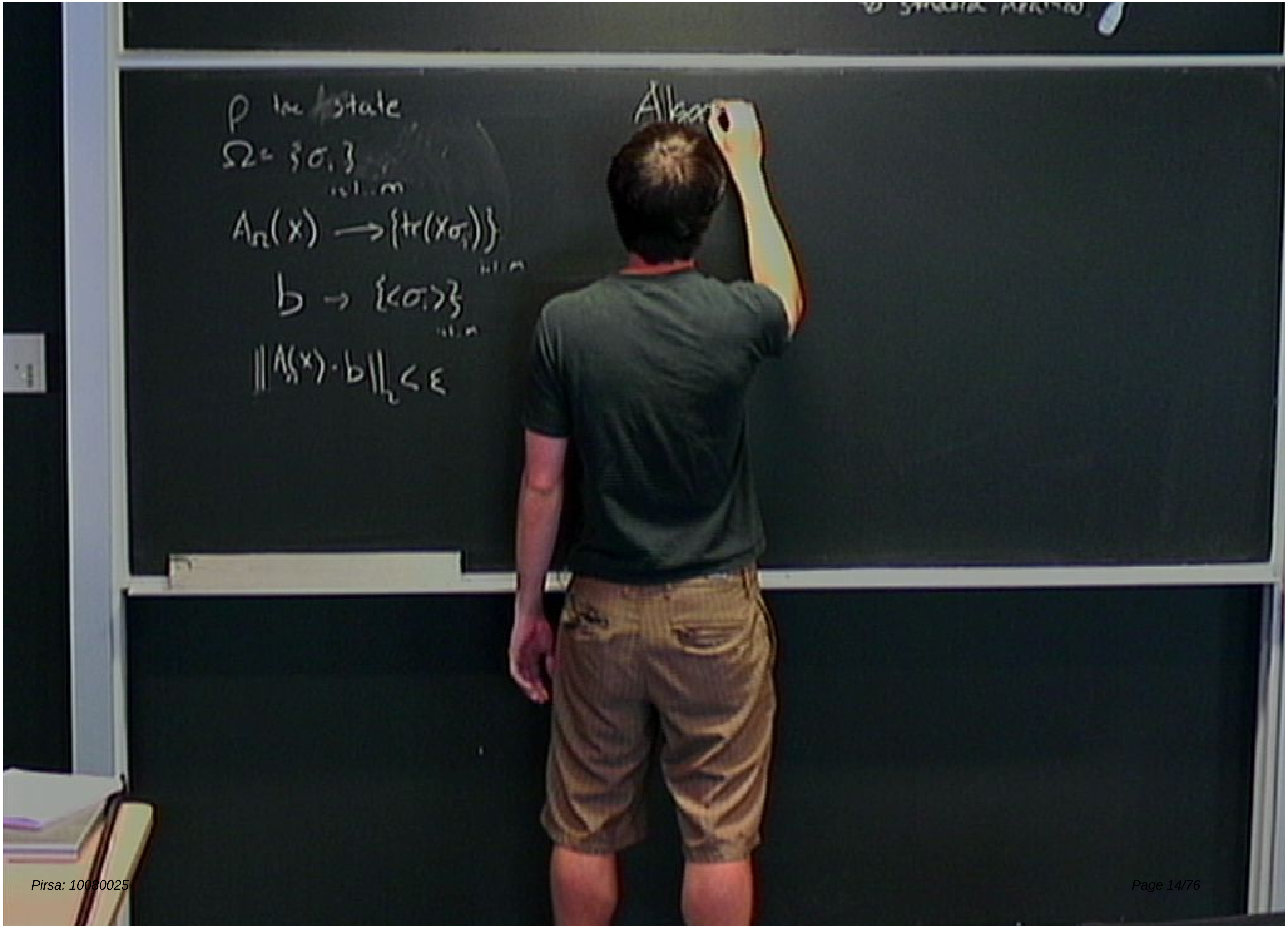


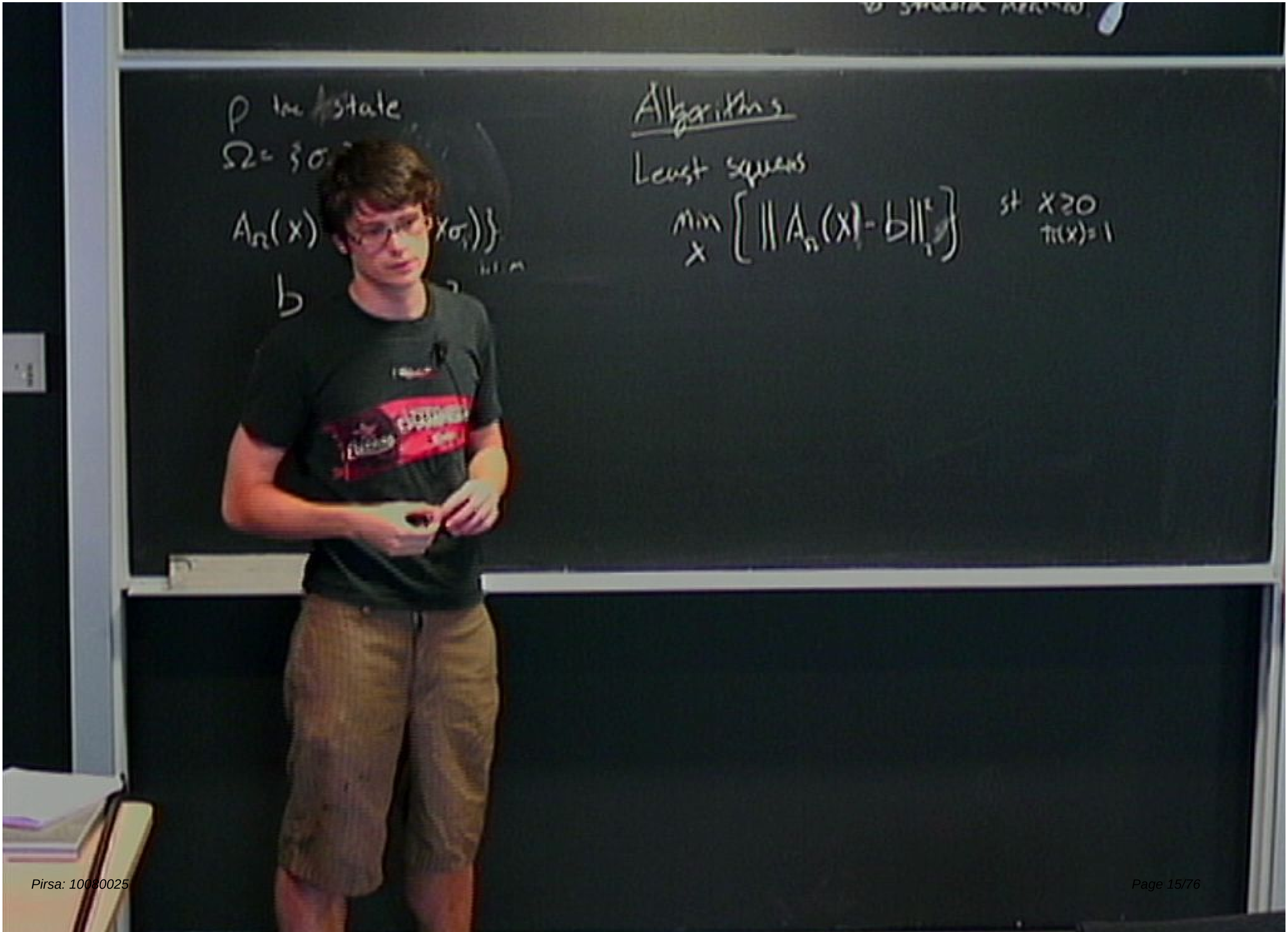

ρ the state
{σ_i} = tr(Xσ_i)

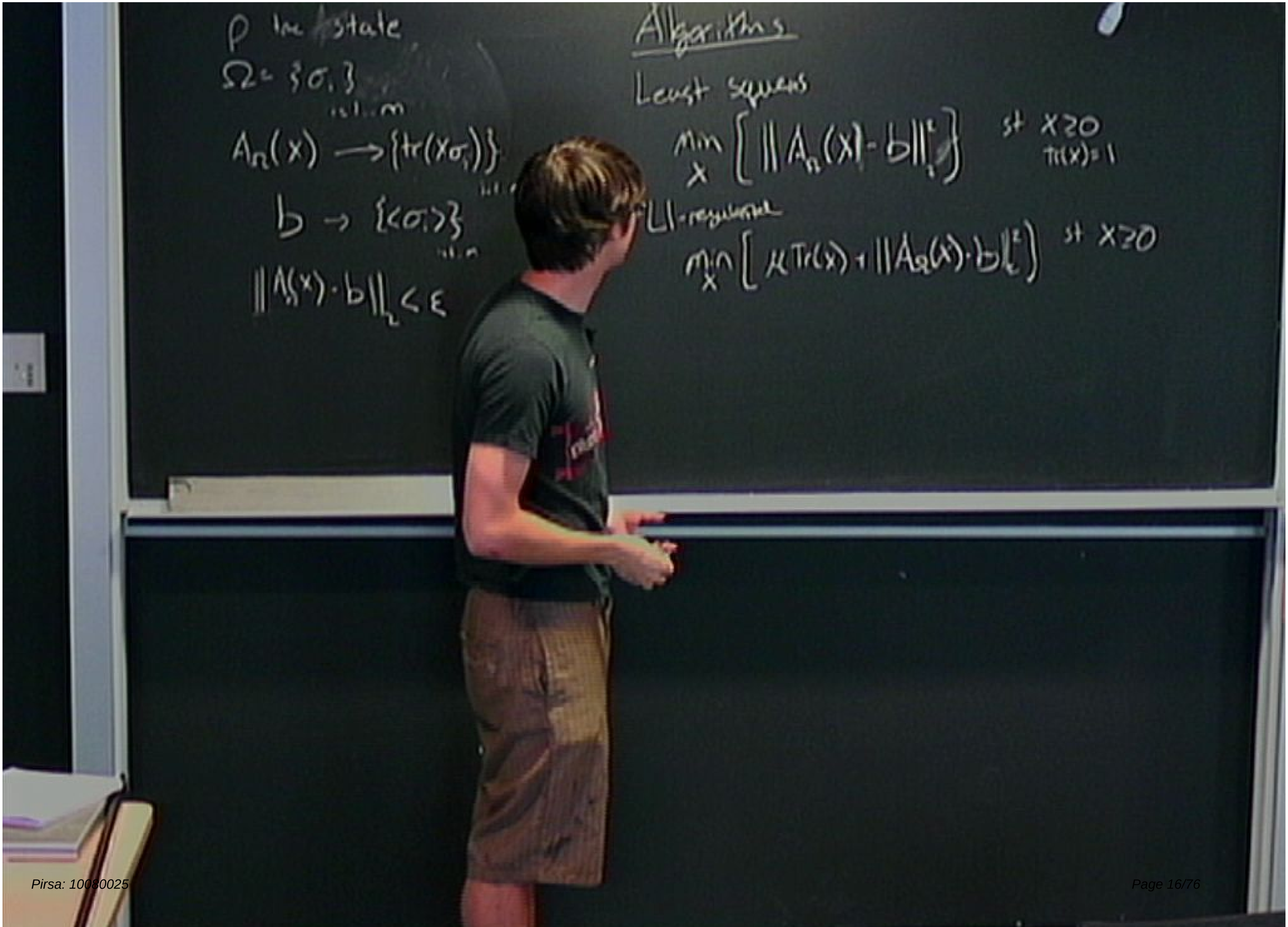

ρ the state
Ω = {σ_i}

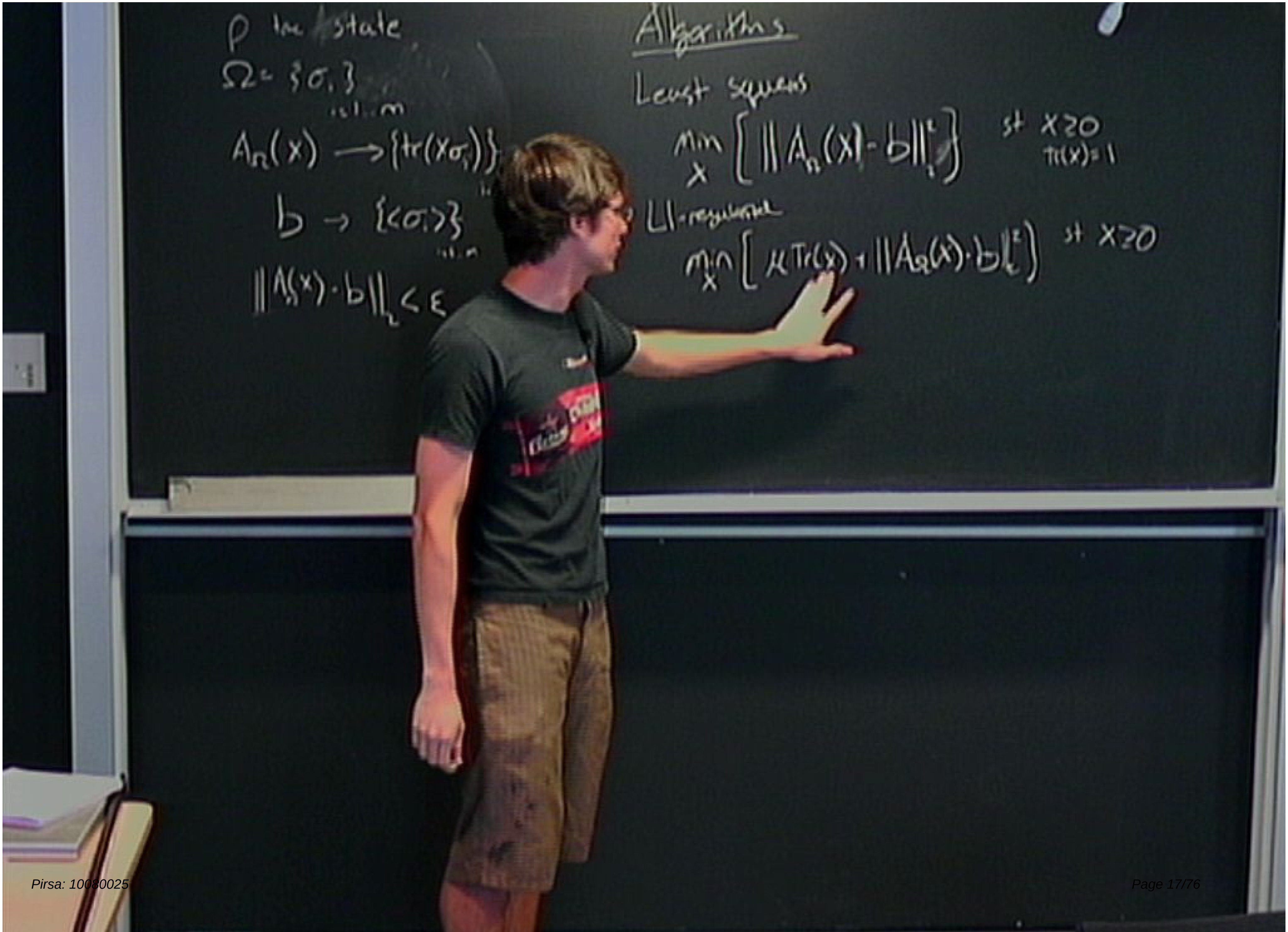

ρ the state

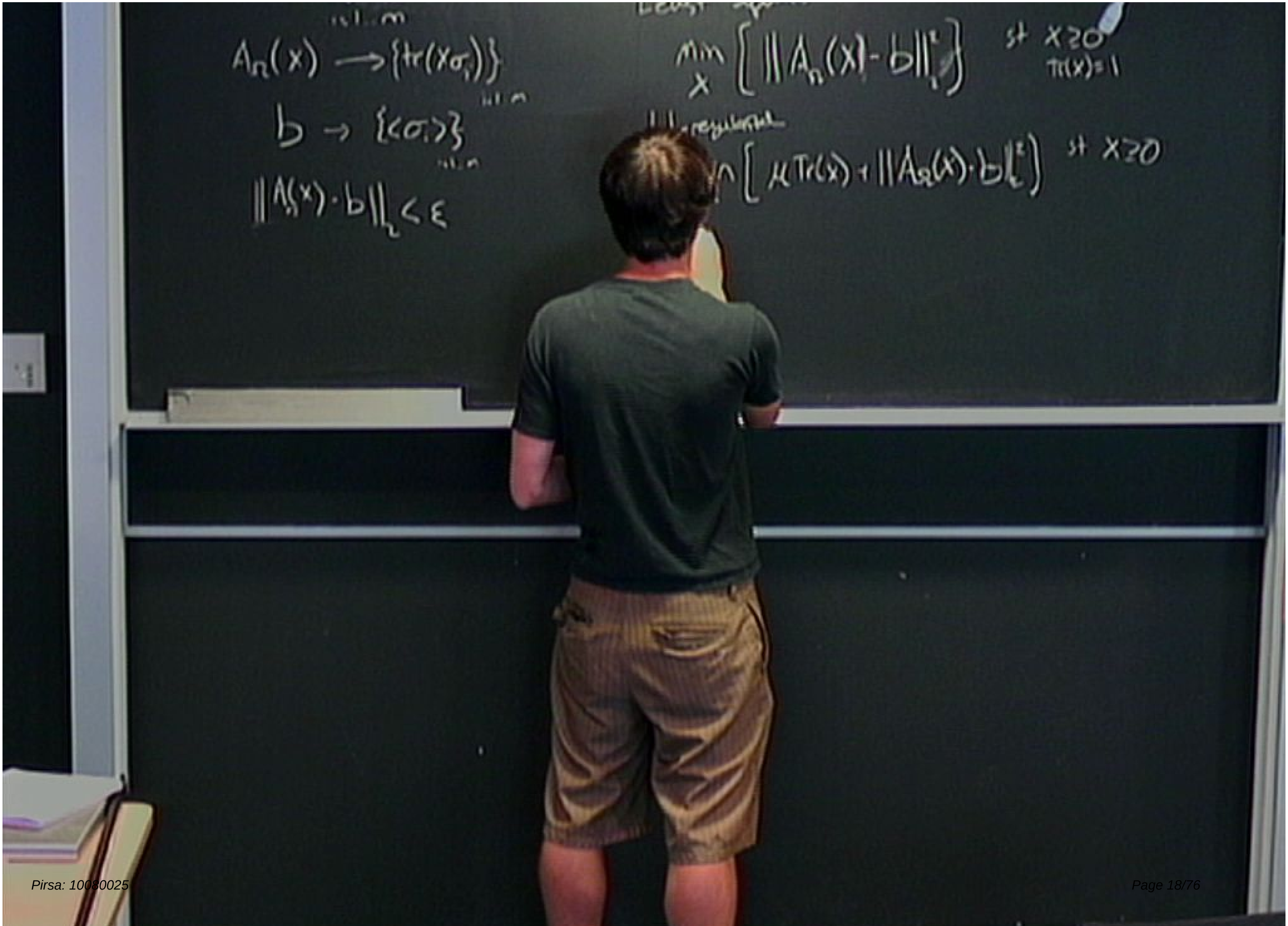

ρ the state
{σi}
(X) → {tr(Xσi)}
b → {<σi>}

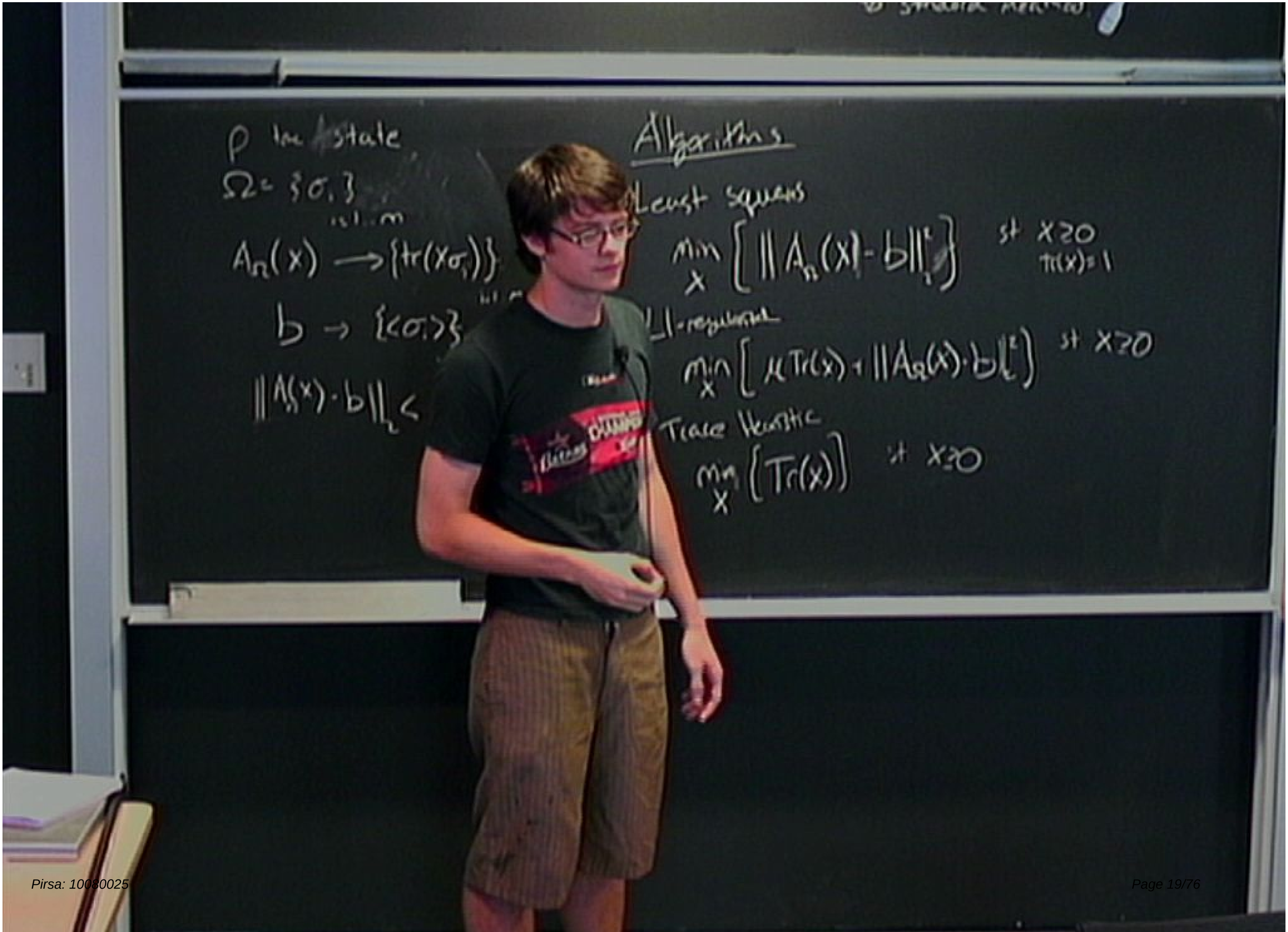

ρ the state
Ω = {σᵢ} i=1..m
A_Ω(X) → {tr(Xσᵢ)} i=1..m
b → {<σᵢ>} i=1..m
‖A_Ω(X) - b‖₂ < ε

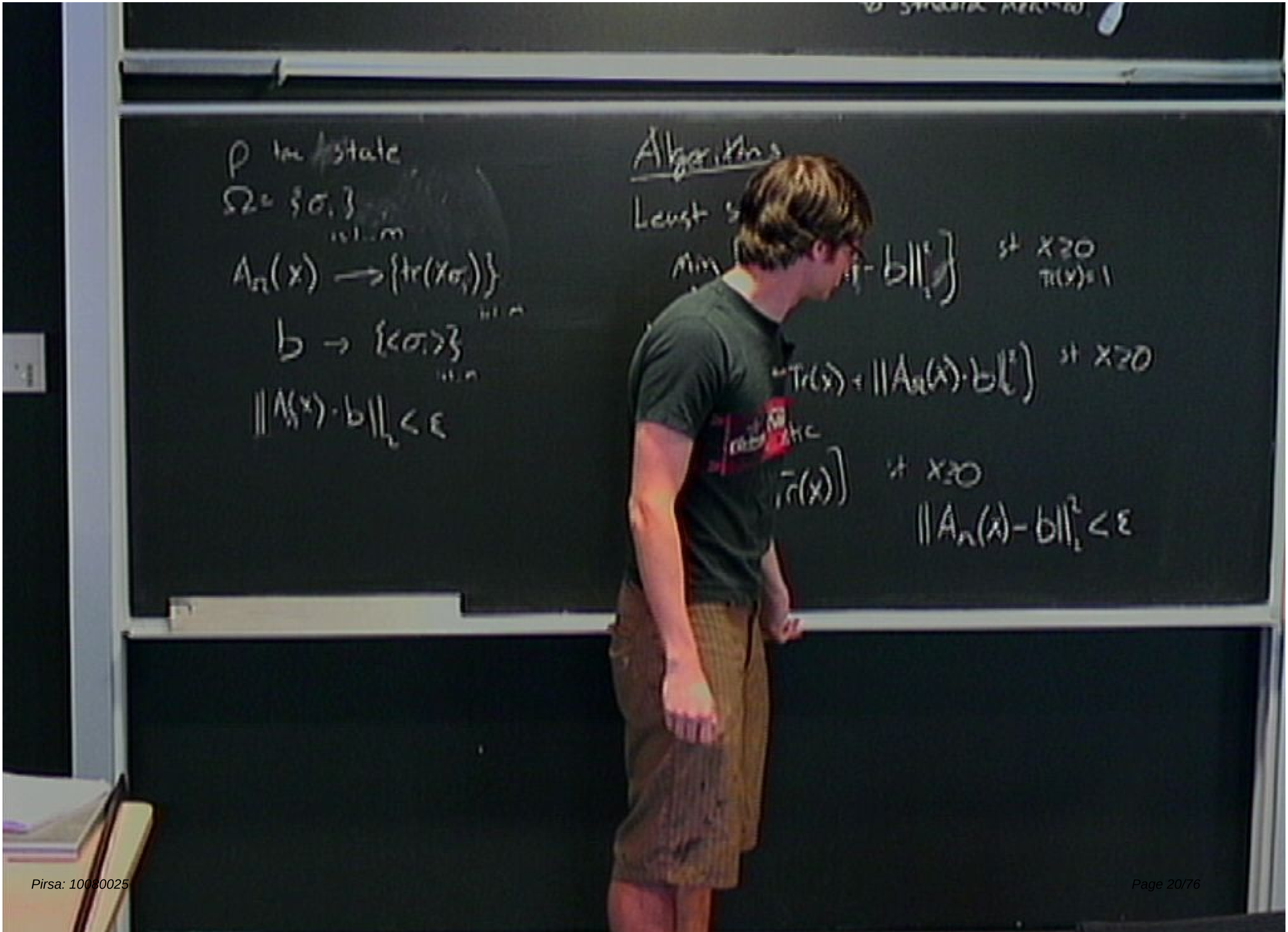

ρ the state
Algorithms
Least squares
min x { ||A_Ω(x) - b||² } st x ≥ 0, Tr(x) = 1

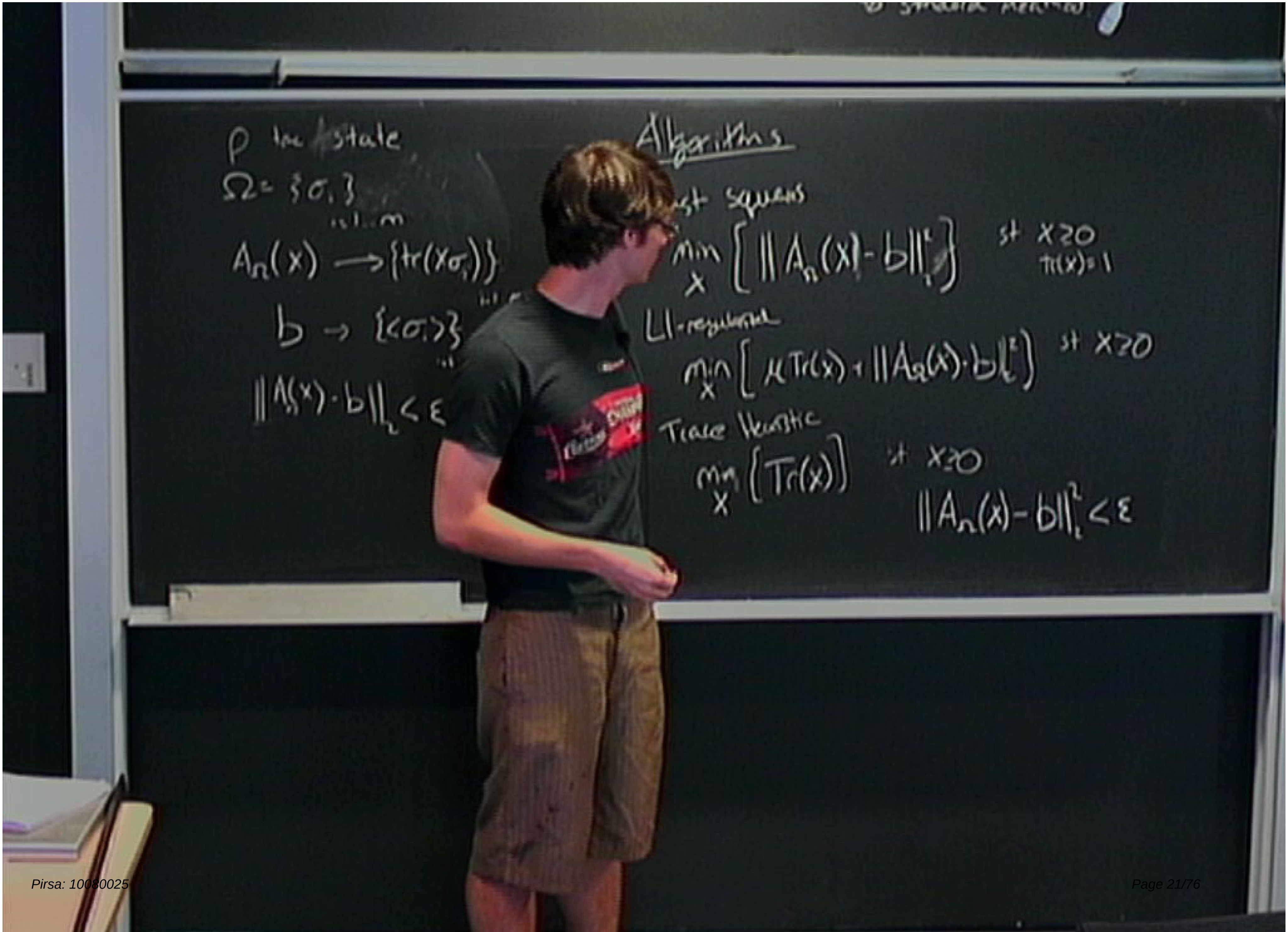

ρ the state
Ω = {σi}
i=1..m
AΩ(X) → {tr(Xσi)}
b → {<σi>}
||AΩ(X) - b||2 < ε
Algorithms
Least squares
min X [||AΩ(X) - b||2^2] st X≥0 Tr(X)=1
L1-regularized
min X [μ Tr(X) + ||AΩ(X) - b||2^2] st X≥0

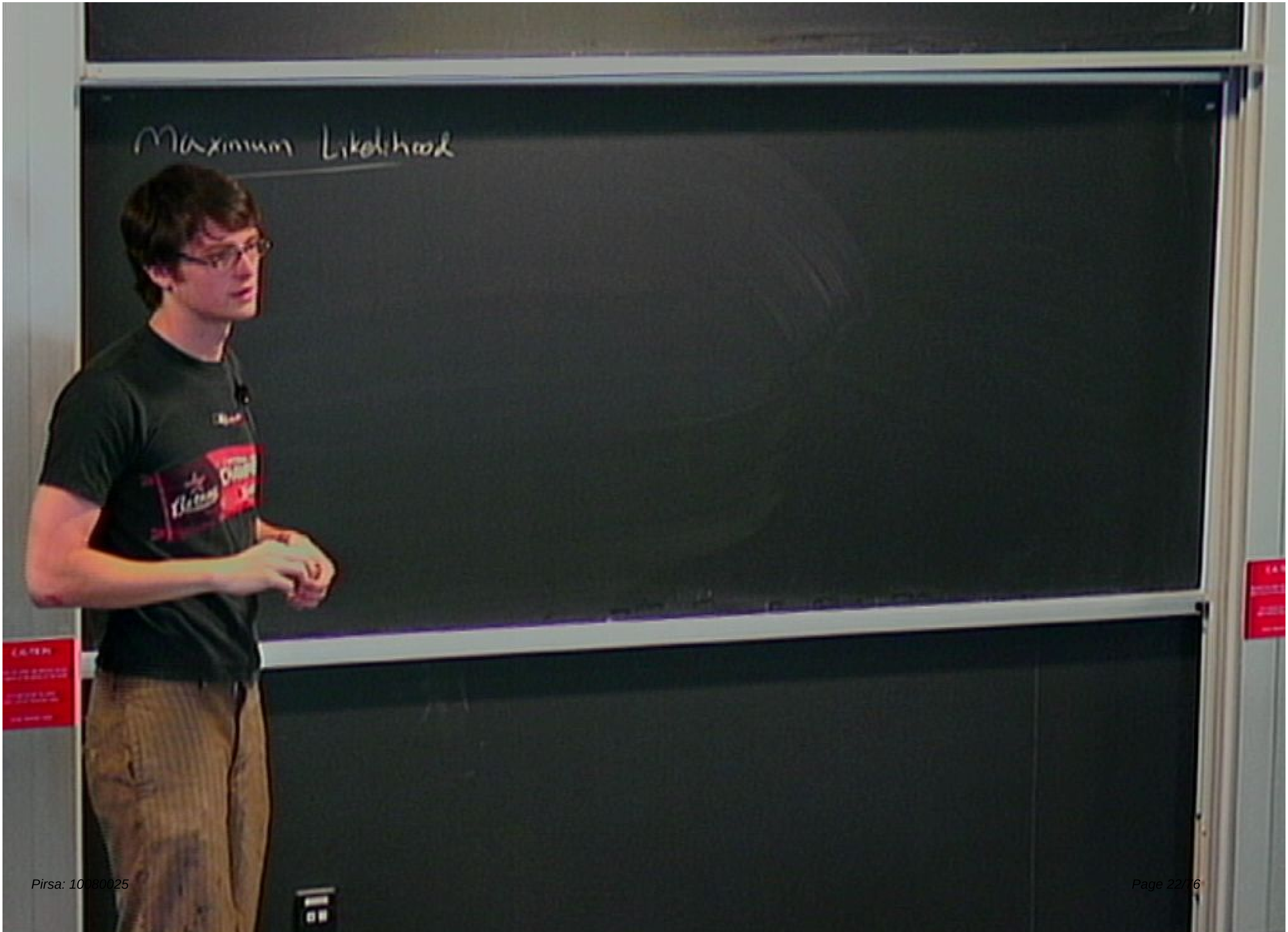

ρ the state
Ω = {σ_i}
A_Ω(X) → {tr(Xσ_i)}
b → {<σ_i>}
||A_Ω(X) - b||_2 < ε
Algorithms
Least squares
min_X [||A_Ω(X) - b||_2^2] st X ≥ 0, Tr(X) = 1
L1-regularized
min_X [μ Tr(X) + ||A_Ω(X) - b||_2^2] st X ≥ 0

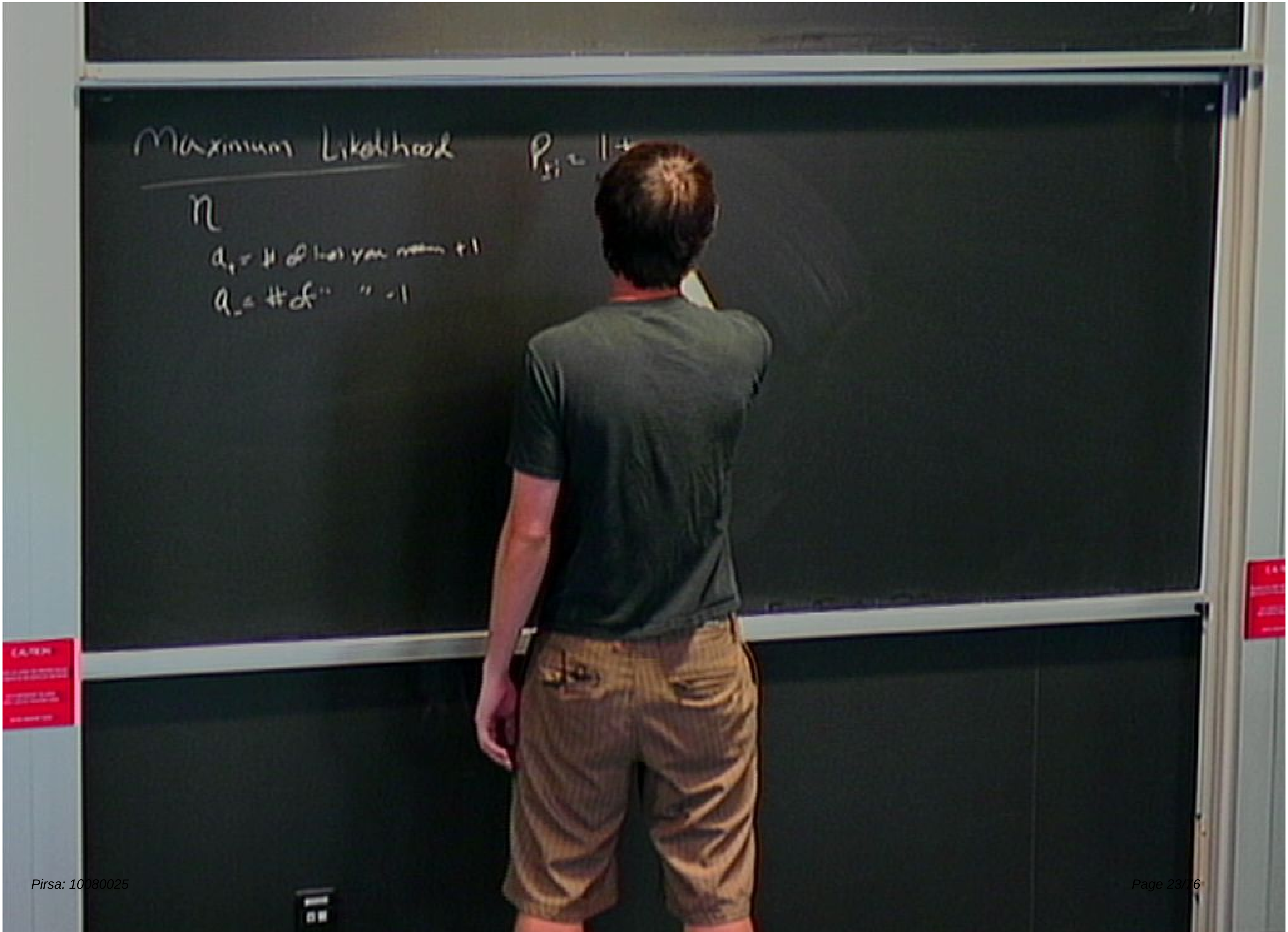

A_n(X) → {tr(Xσ_i)}
b → {<σ_i>}
||A_n(X) - b||_2 < ε
min_X { ||A_n(X) - b||_2^2 }
st X ≥ 0
Tr(X) = 1
st X ≥ 0

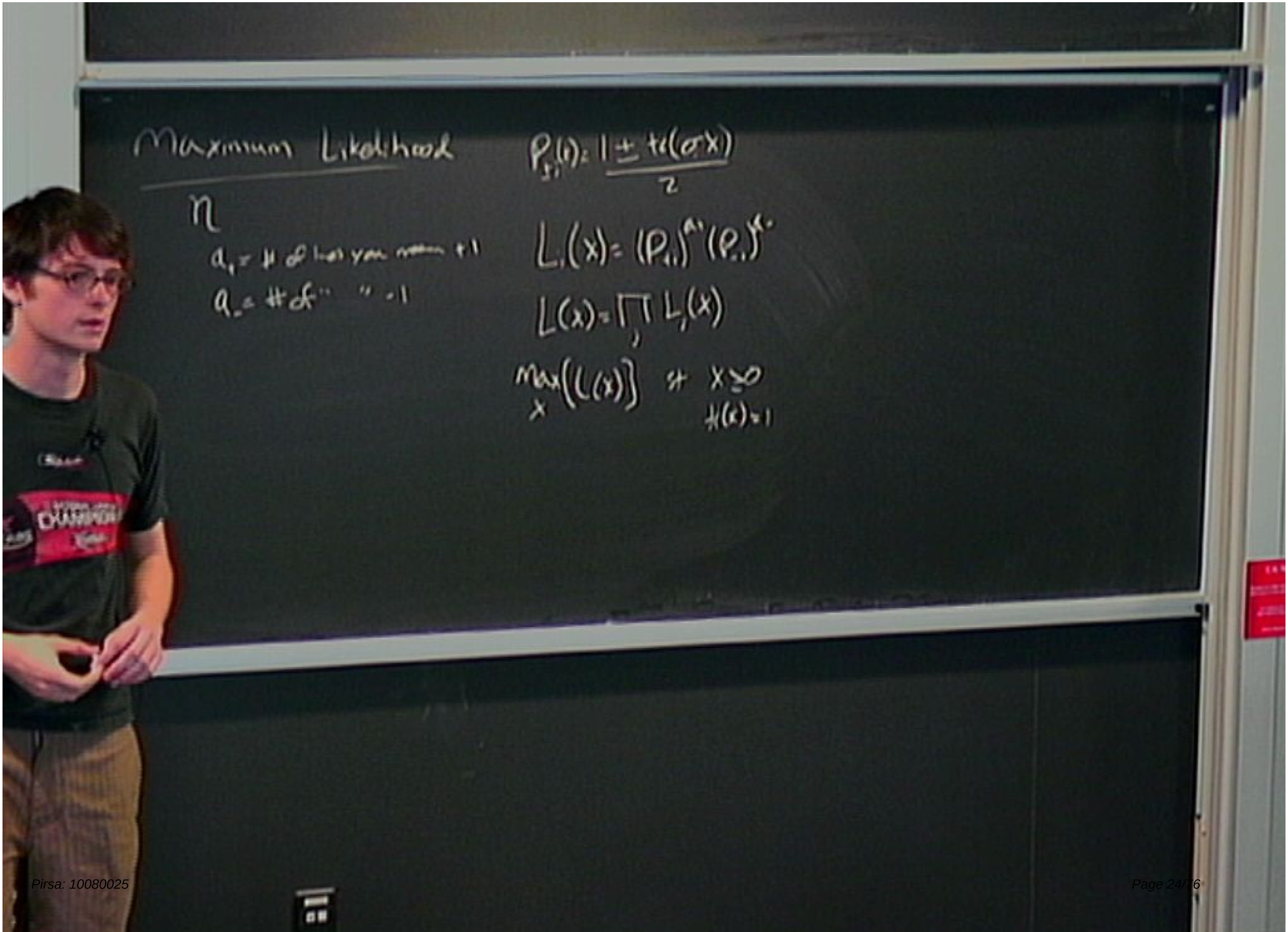

Algorithms
Least squares
Trace Heuristic

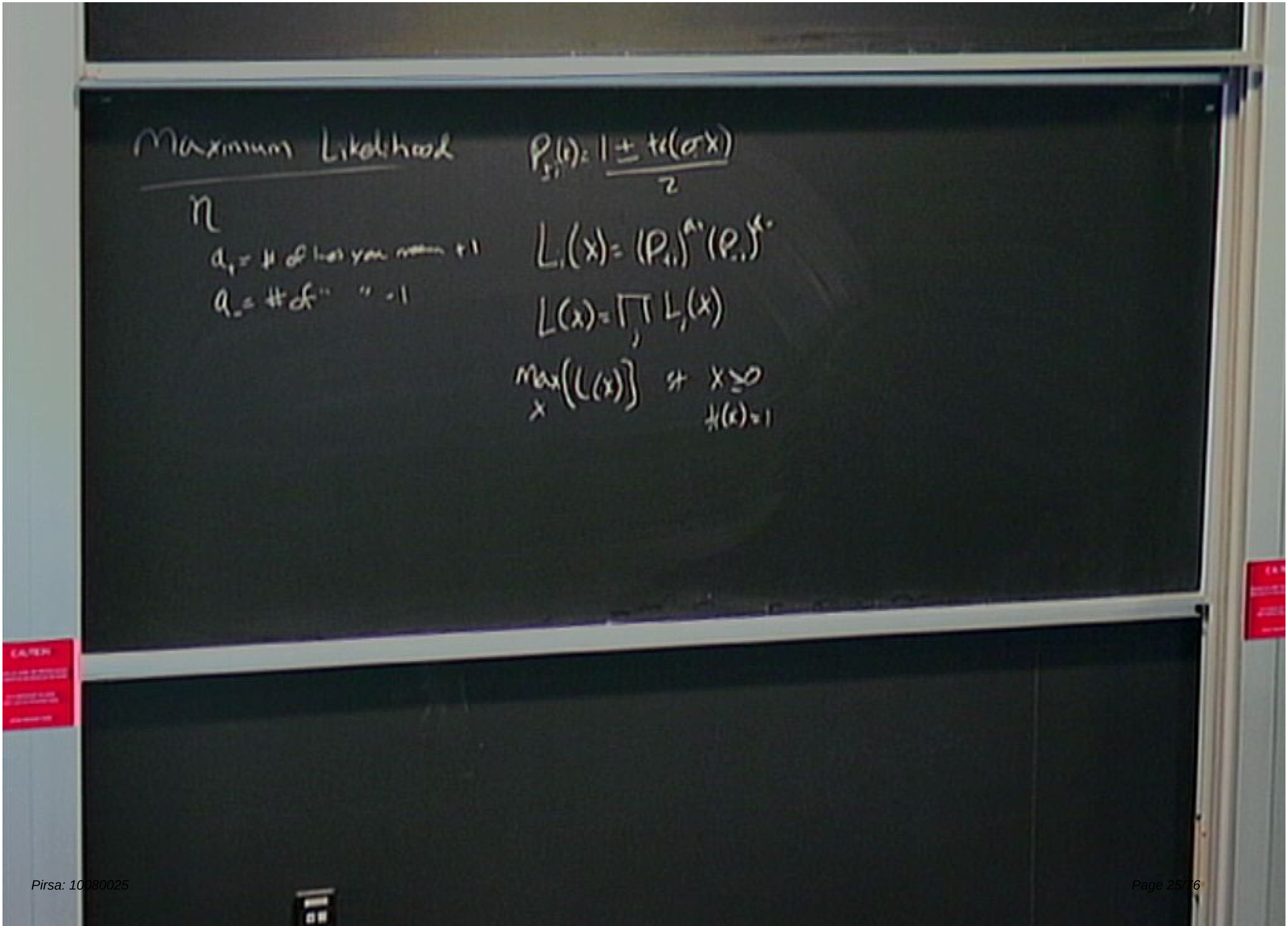

ρ
Algorithms
Ω = {σ_i}
A_Ω(X) → {tr(Xσ_i)}
b → {<σ_i>}
st X≥0
Tr(X)=1
st X≥0
st X≥0
||A_n(X)-b||_2^2 < ε


Algorithms
ρ the state
Least squares
L1-regularized
Trace Heuristic
st X≥0
Tr(X)=1


Maximum Likelihood


Maximum Likelihood
n
" -1


Maximum Likelihood
n
a+ = # of times you measure +1
a- = # of " " -1
P±1(i) = (1 ± tr(σi X))/2
Li(X) = (P+1)^a+ (P-1)^a-
L(X) = ∏i Li(X)
max_X {L(X)} st X ≥ 0
tr(X) = 1



Maximum Likelihood
n
a+ = # of times you measure +1
a- = # of " " -1
P±1(x) = 1 ± tr(σ x) / 2
Li(x) = (P+1)^a+ (P-1)^a-
L(x) = ∏ Li(x)
max [L(x)] st x ≥ 0
tr(x) = 1

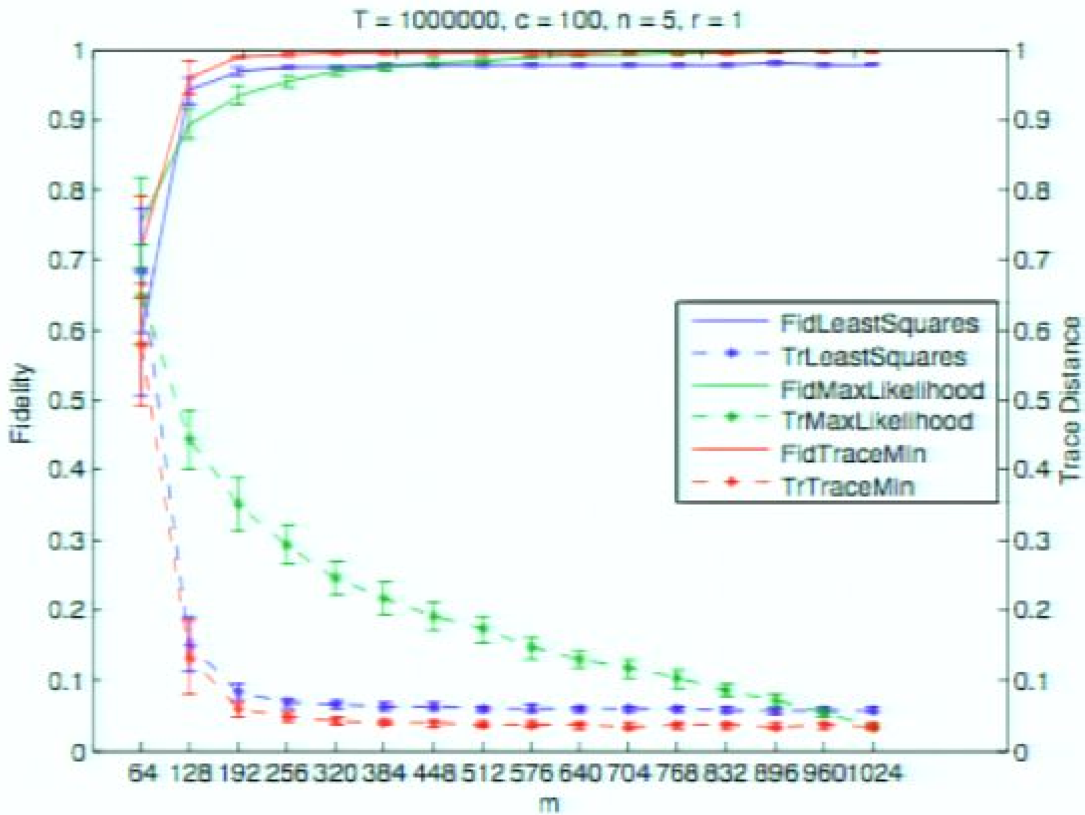
Variables for Testing

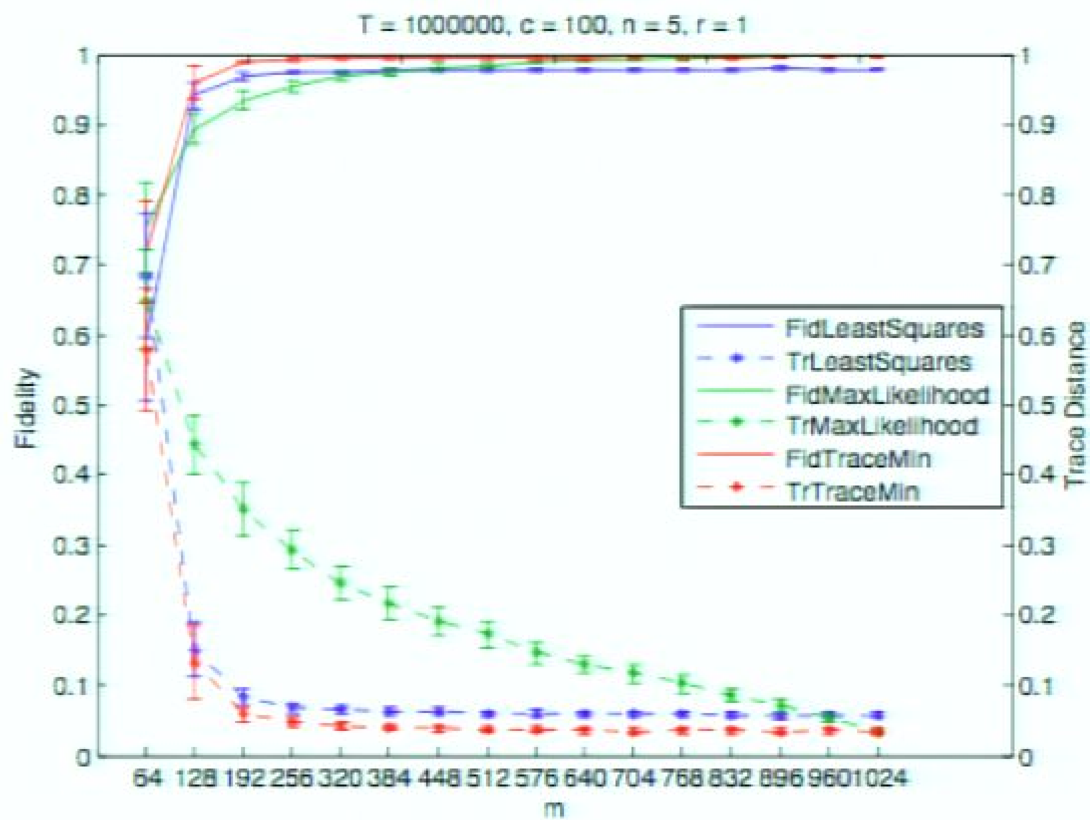
c = 1, 25, 100

m = 2rd ... d^2

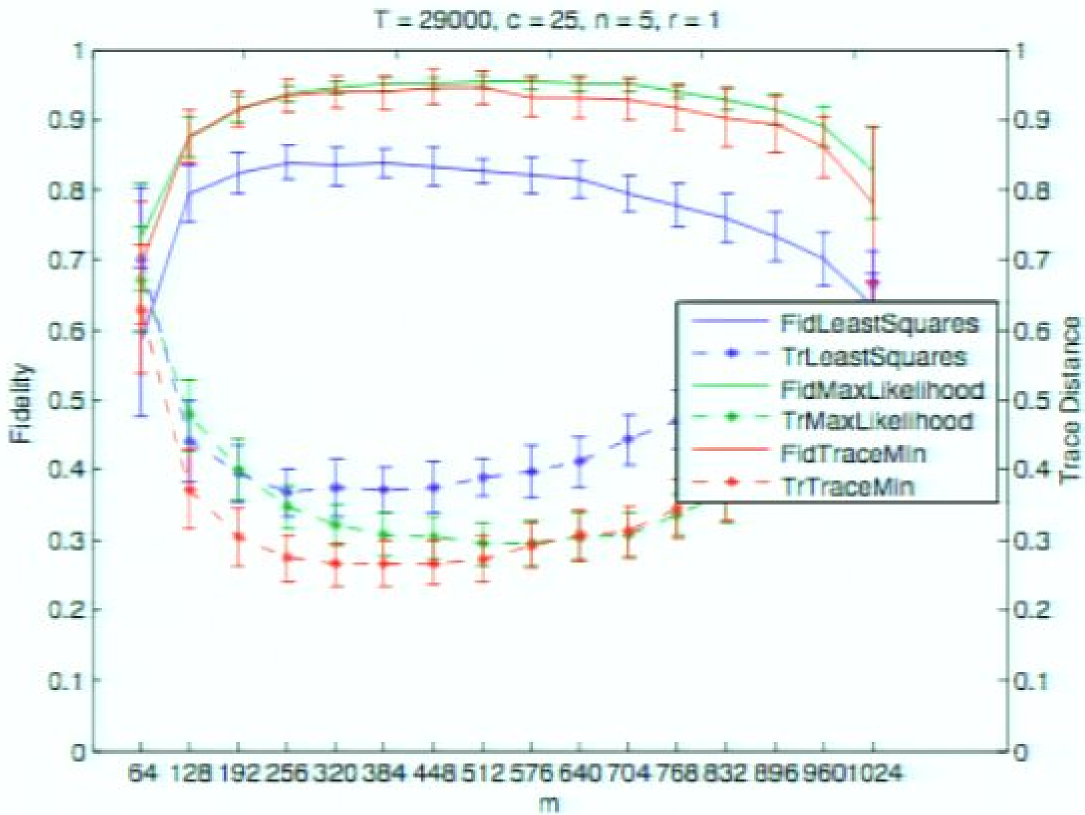
n = 5, r = 1,2

k = 60

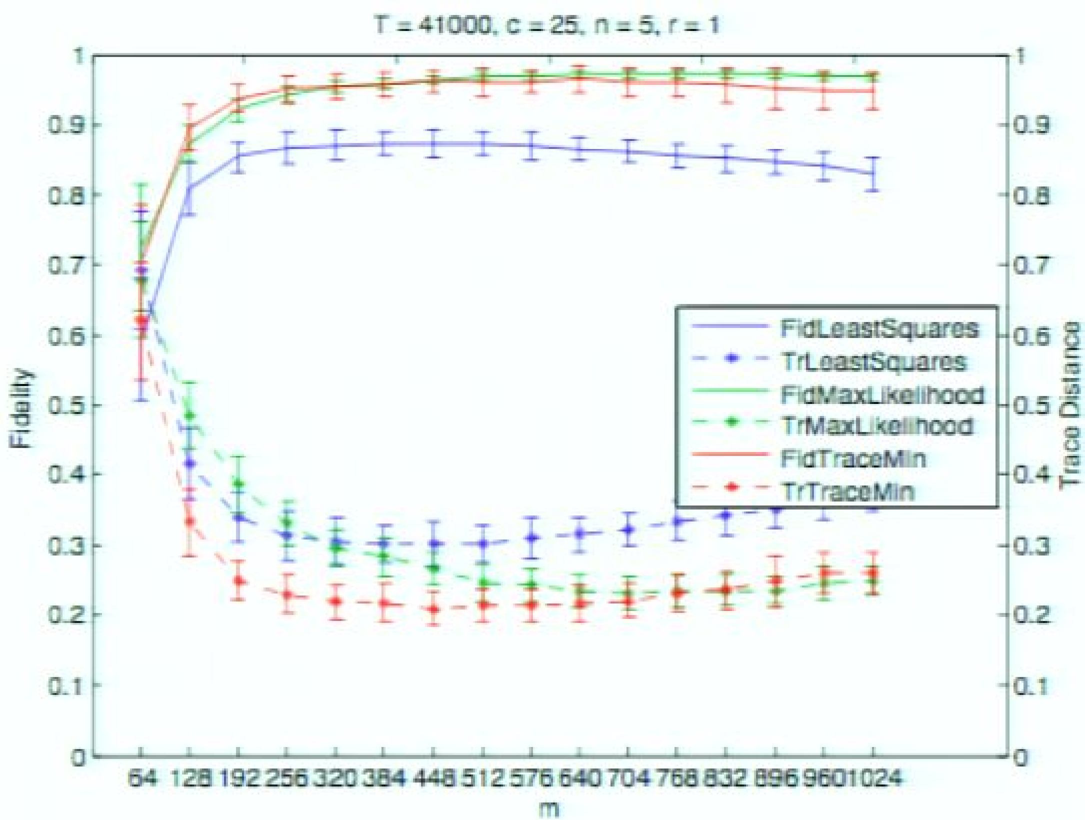

T = 1000000, c = 100, n = 5, r = 1
Fidelity
Trace Distance
m
FidLeastSquares
TrLeastSquares
FidMaxLikelihood
TrMaxLikelihood
FidTraceMin
TrTraceMin
64 128 192 256 320 384 448 512 576 640 704 768 832 896 960 1024
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

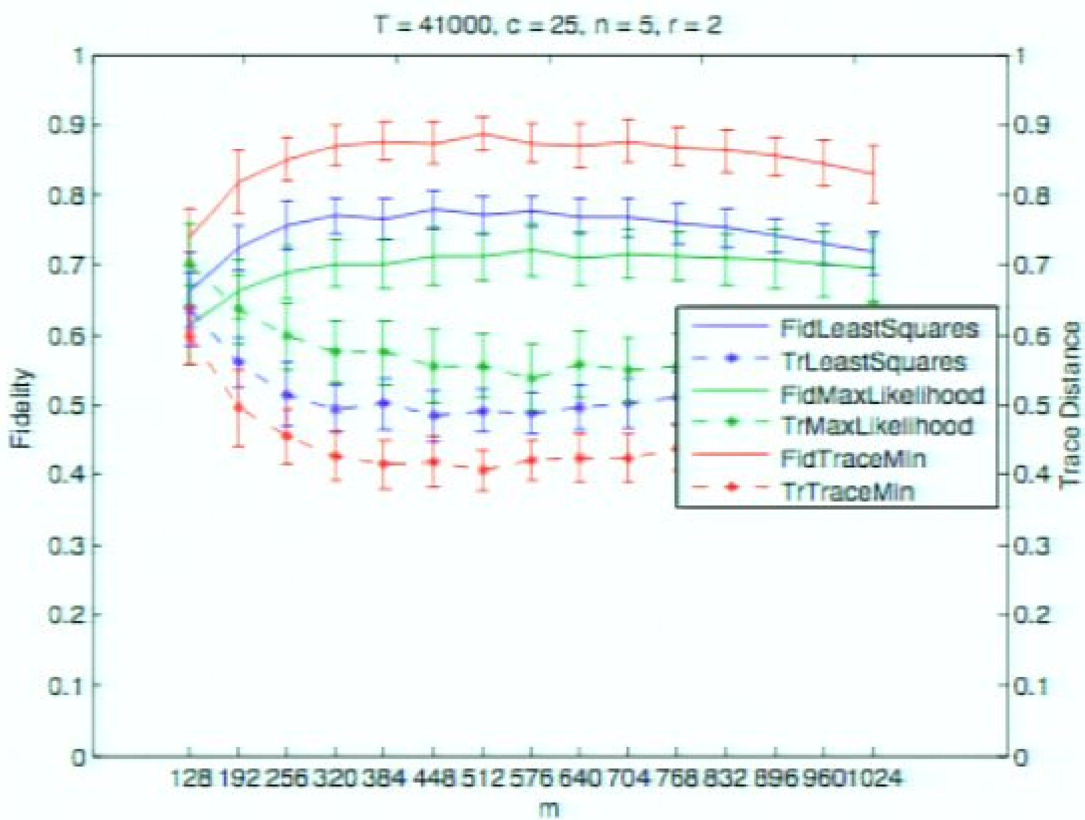


T = 1000000, c = 100, n = 5, r = 1
Fidelity
Trace Distance
m
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
64 128 192 256 320 384 448 512 576 640 704 768 832 896 960 1024
FidLeastSquares
TrLeastSquares
FidMaxLikelihood
TrMaxLikelihood
FidTraceMin
TrTraceMin



T = 29000, c = 25, n = 5, r = 1
Fidelity
Trace Distance
m
64 128 192 256 320 384 448 512 576 640 704 768 832 896 960 1024
FidLeastSquares
TrLeastSquares
FidMaxLikelihood
TrMaxLikelihood
FidTraceMin
TrTraceMin


T = 41000, c = 25, n = 5, r = 1
Fidelity
Trace Distance
m
64 128 192 256 320 384 448 512 576 640 704 768 832 896 960 1024
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
FidLeastSquares
TrLeastSquares
FidMaxLikelihood
TrMaxLikelihood
FidTraceMin
TrTraceMin


T = 41000, c = 25, n = 5, r = 2
Fidelity
Trace Distance
m
128 192 256 320 384 448 512 576 640 704 768 832 896 960 1024
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
FidLeastSquares
TrLeastSquares
FidMaxLikelihood
TrMaxLikelihood
FidTraceMin
TrTraceMin

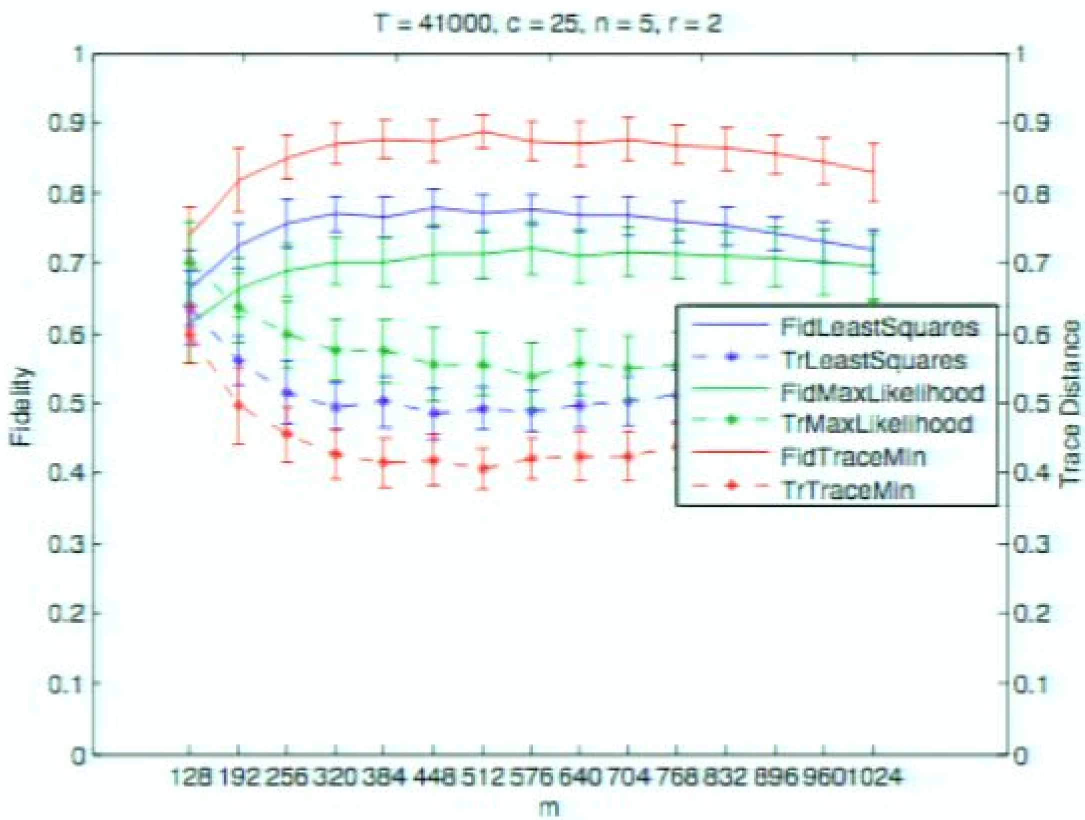
Variables for Testing

c = 1, 25, 100

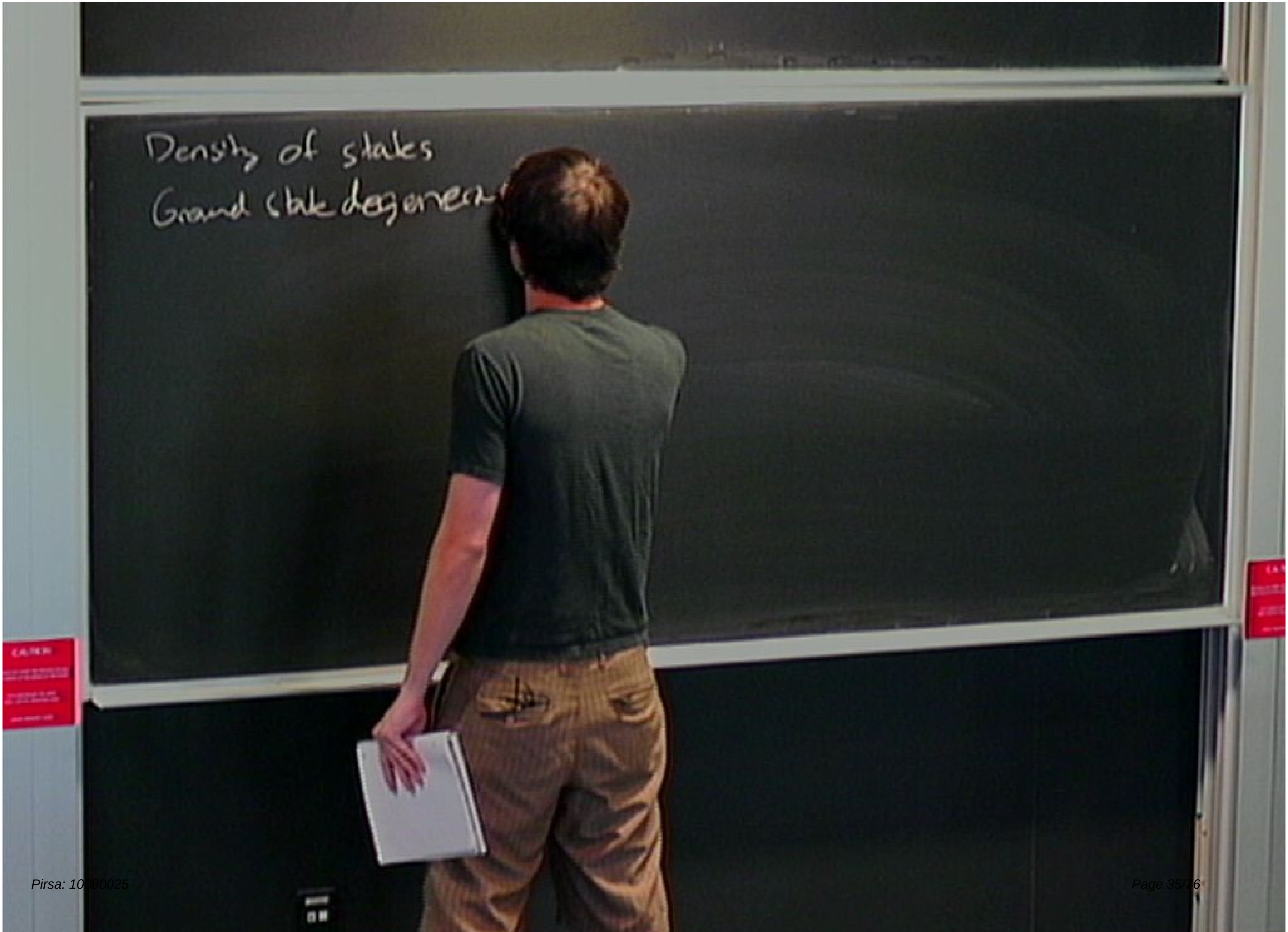
m = 2rd ... d^2

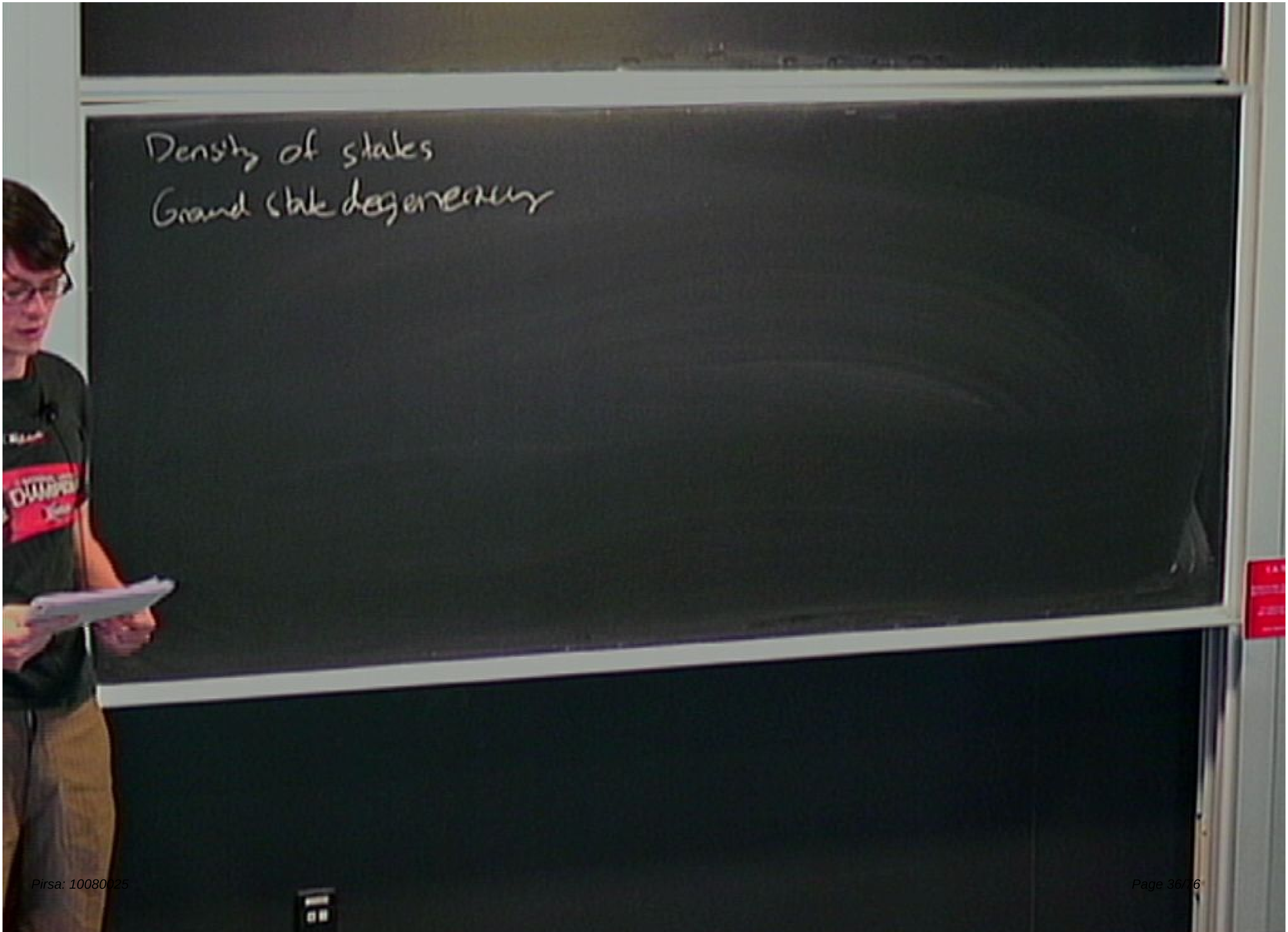
n = 5, r = 1,2

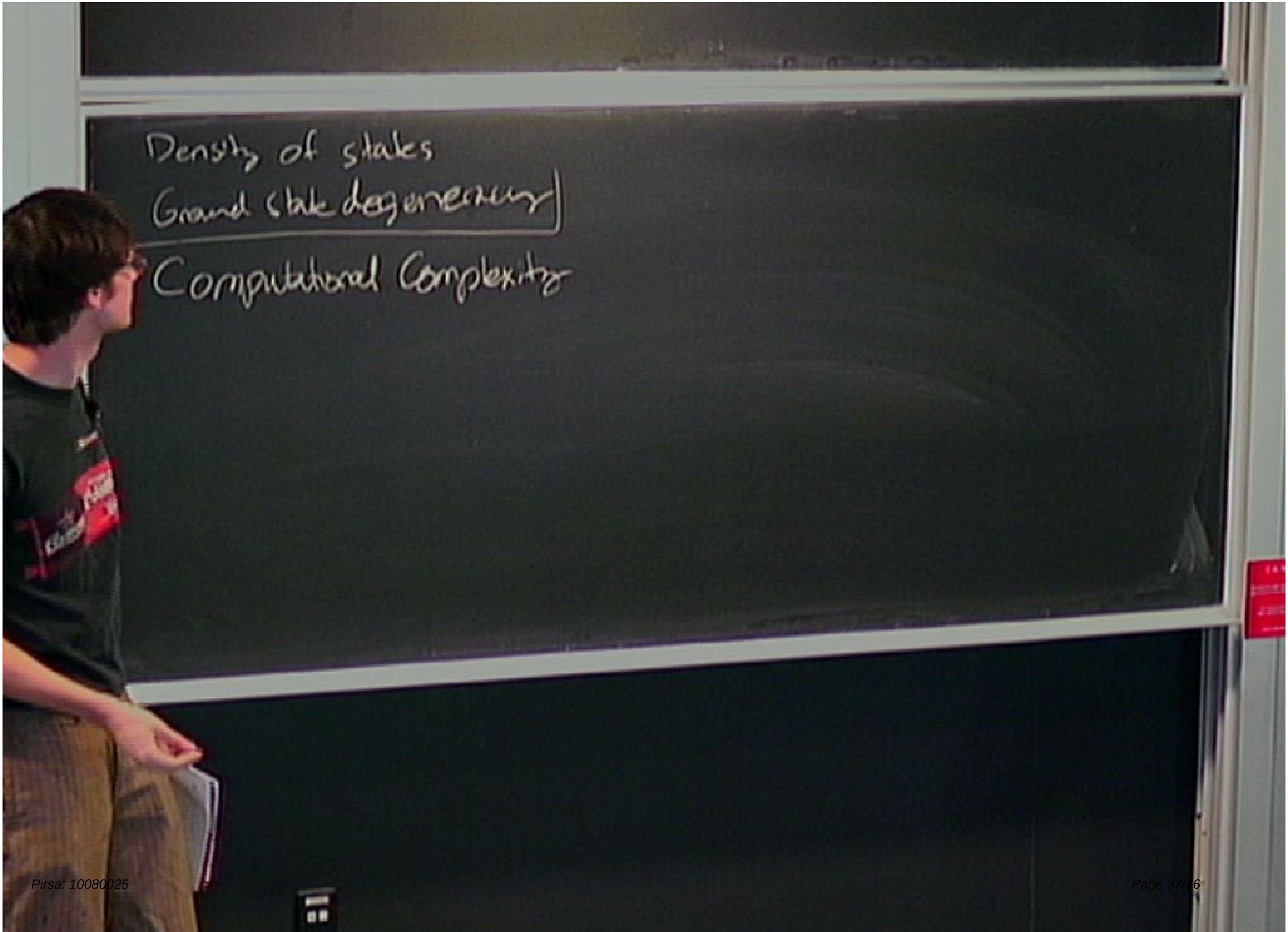
k = 60

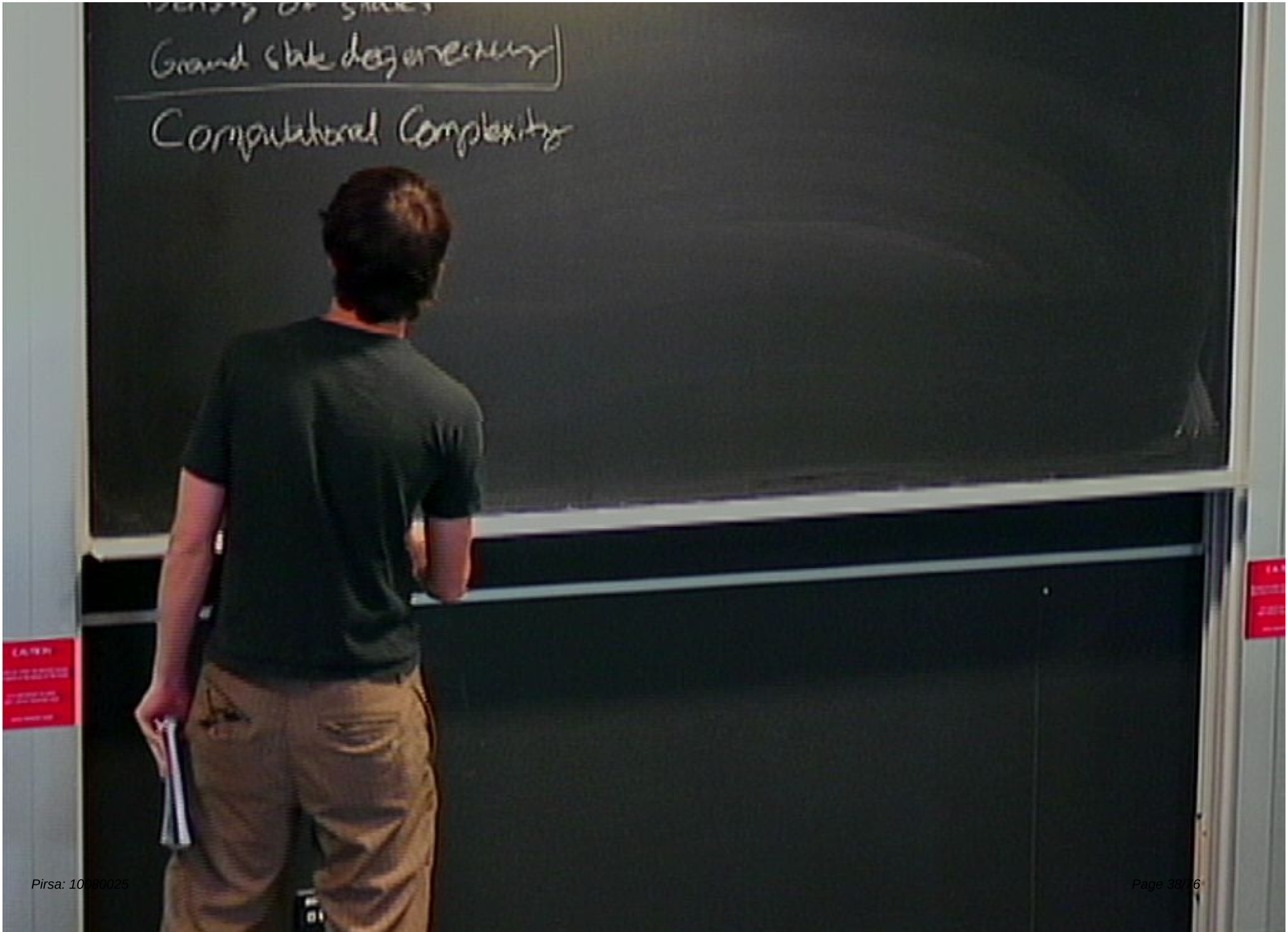


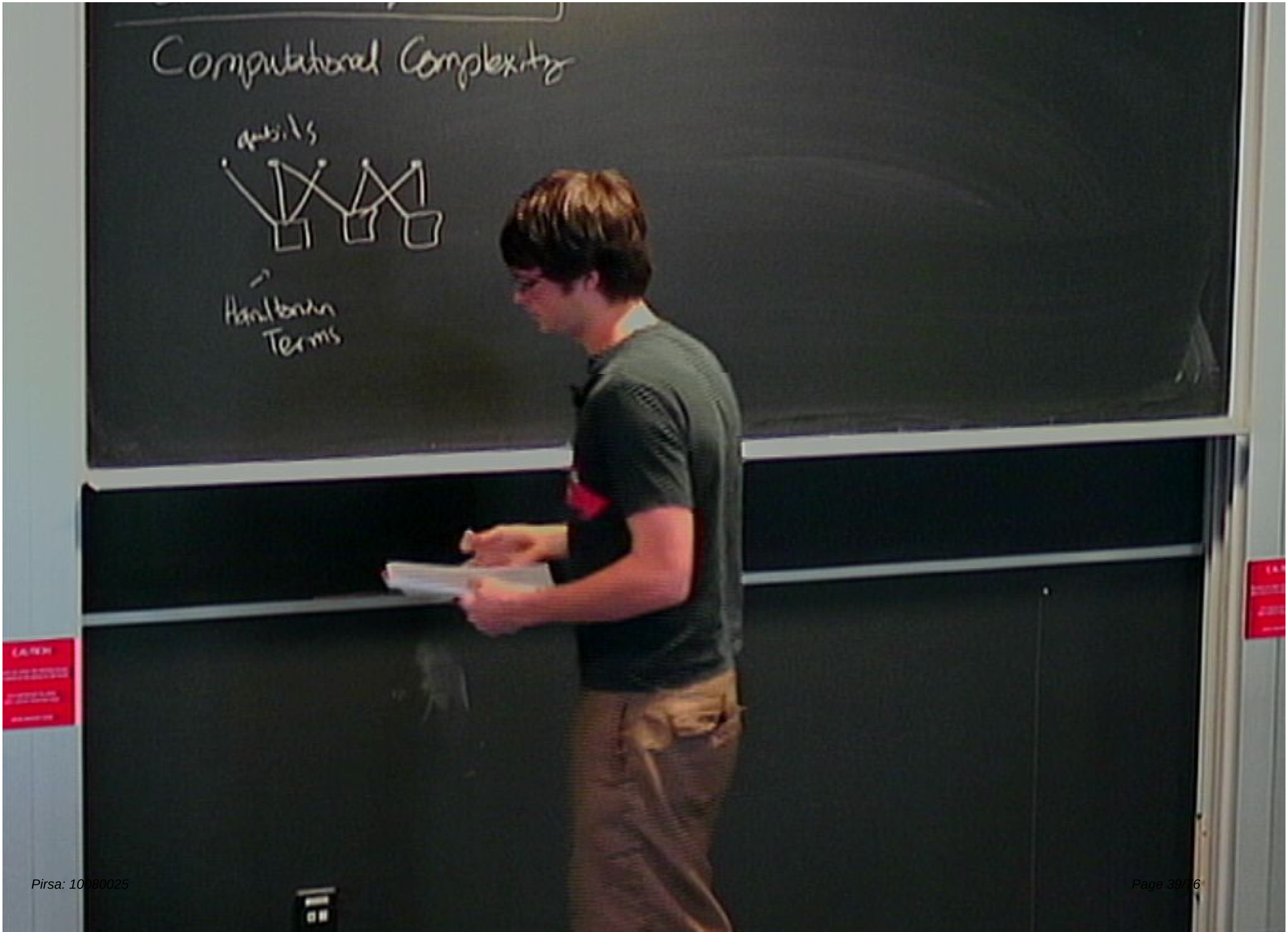
T = 41000, c = 25, n = 5, r = 2
Fidelity
Trace Distance
m
FidLeastSquares
TrLeastSquares
FidMaxLikelihood
TrMaxLikelihood
FidTraceMin
TrTraceMin
128 192 256 320 384 448 512 576 640 704 768 832 896 960 1024
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

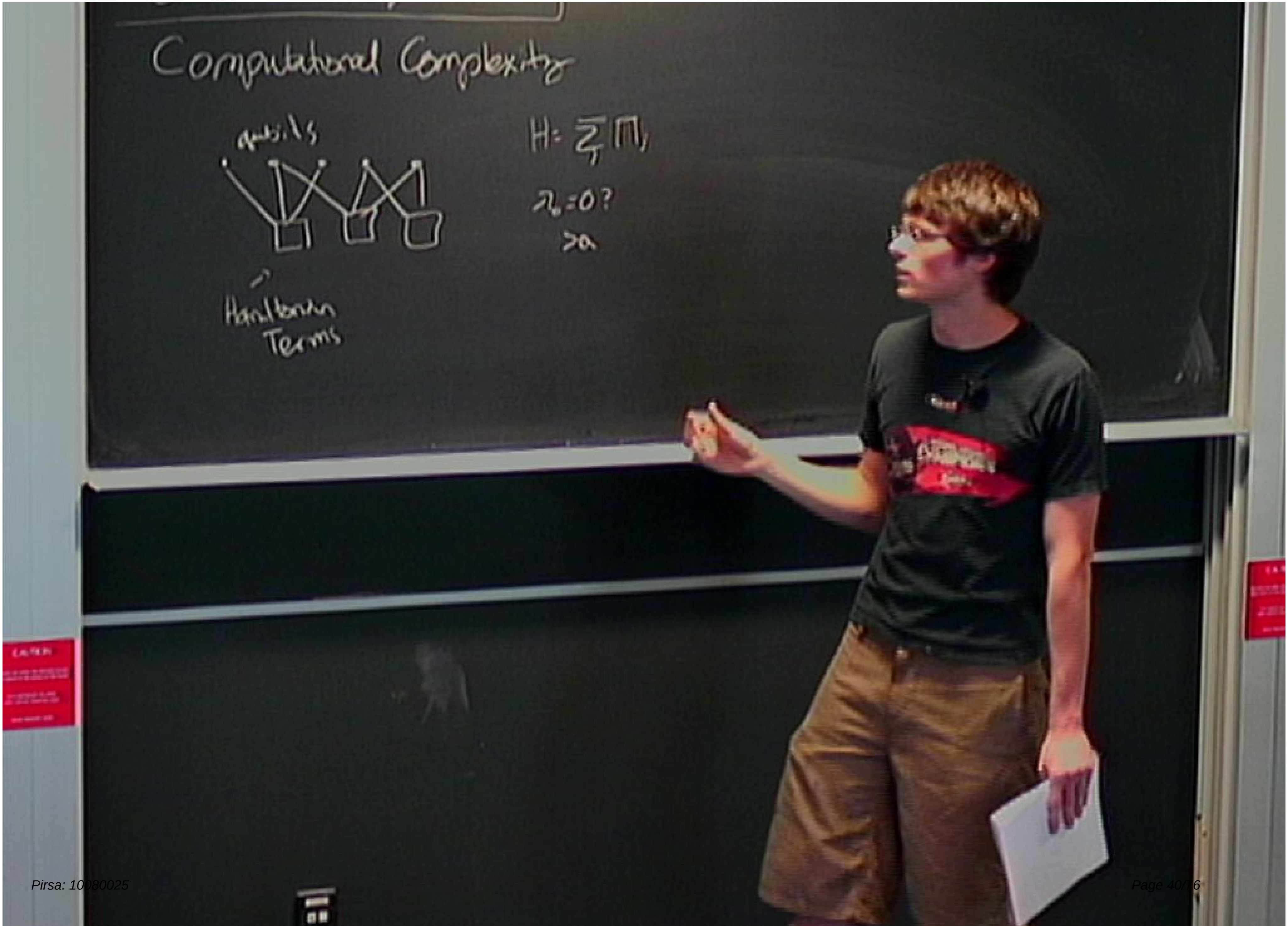

Density of states
Ground state degenera

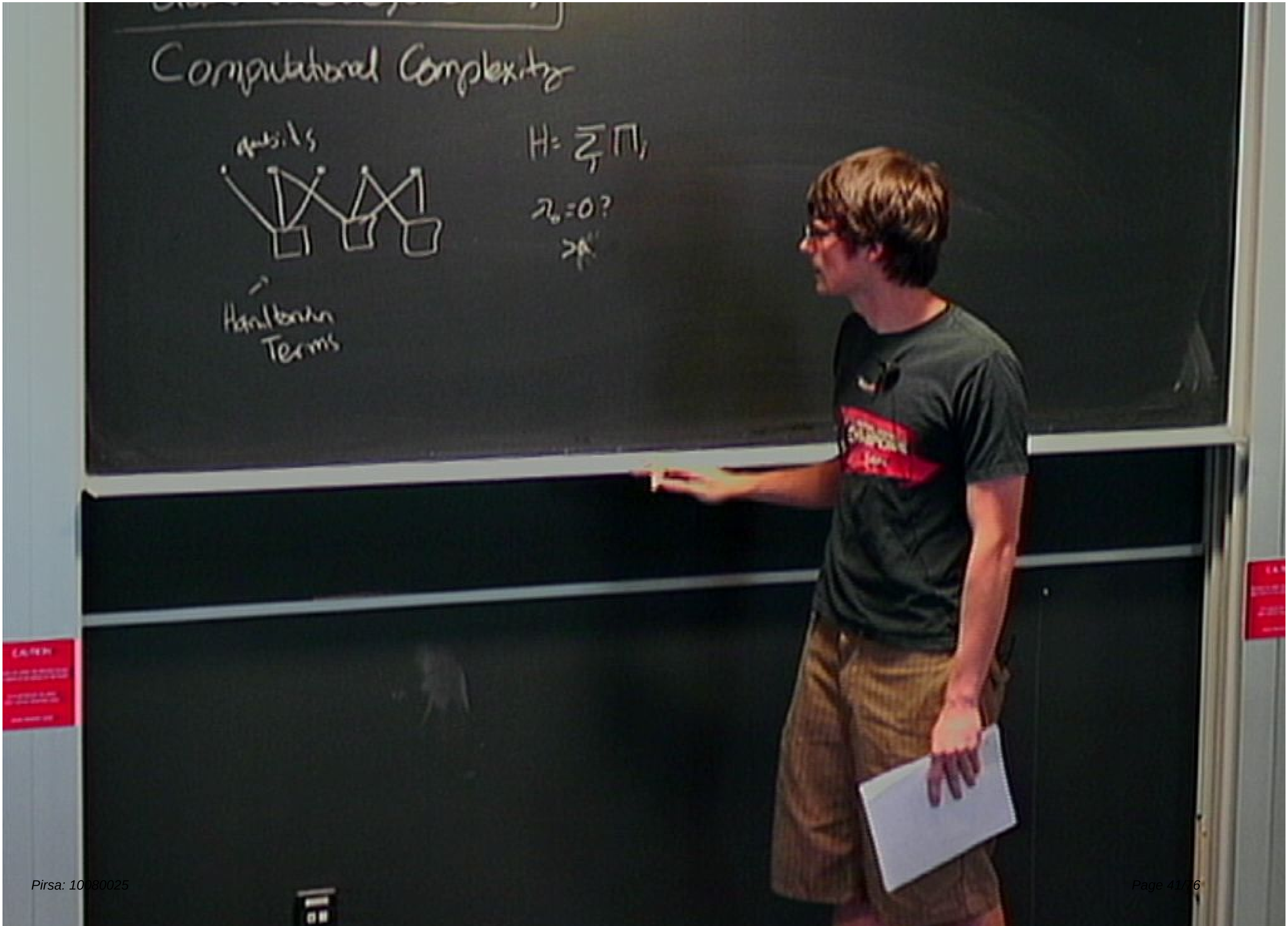

Density of states
Ground state degeneracy

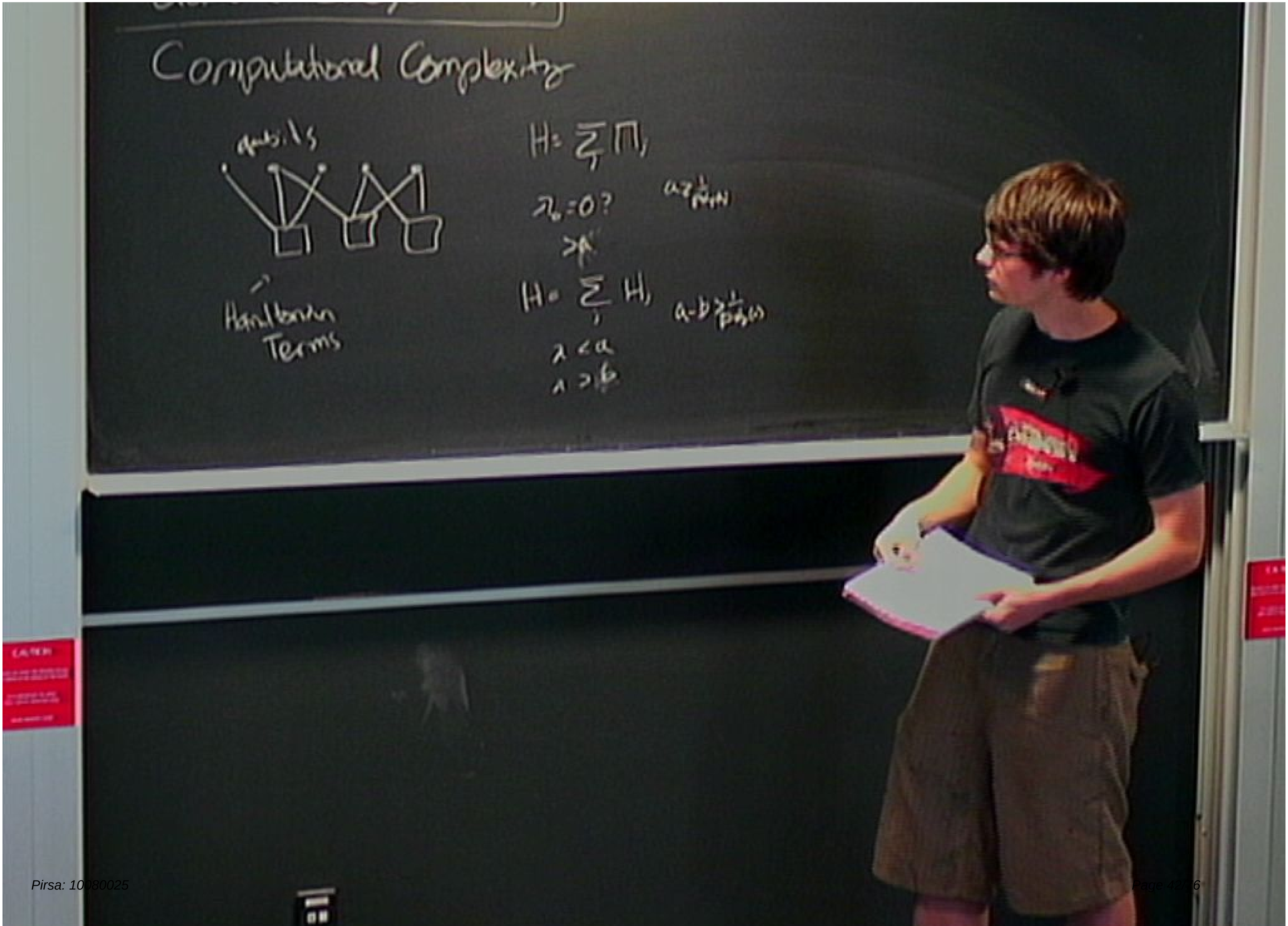

Density of states
Ground state degeneracy
Computational Complexity

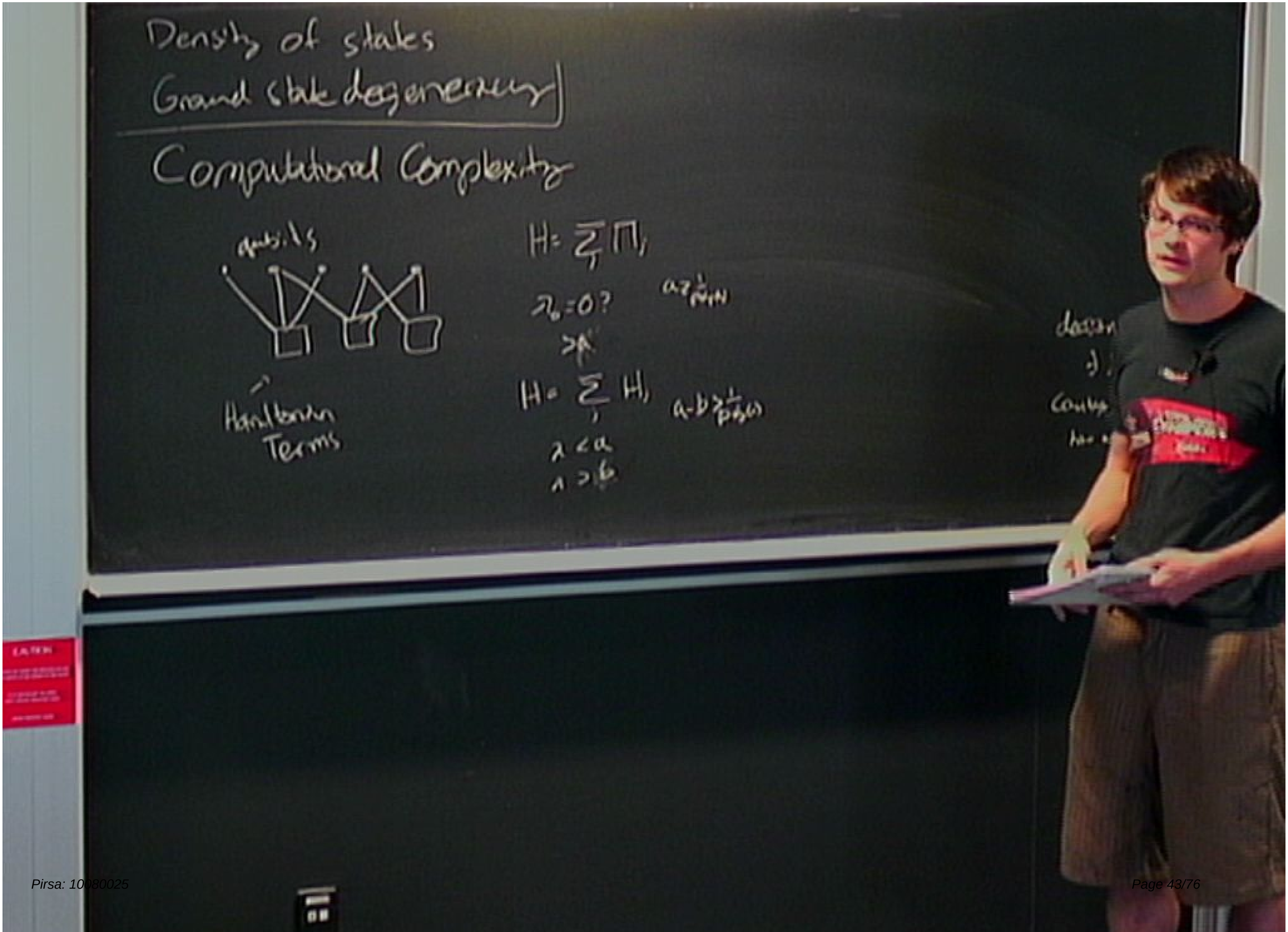

Ground state degeneracy
Computational Complexity

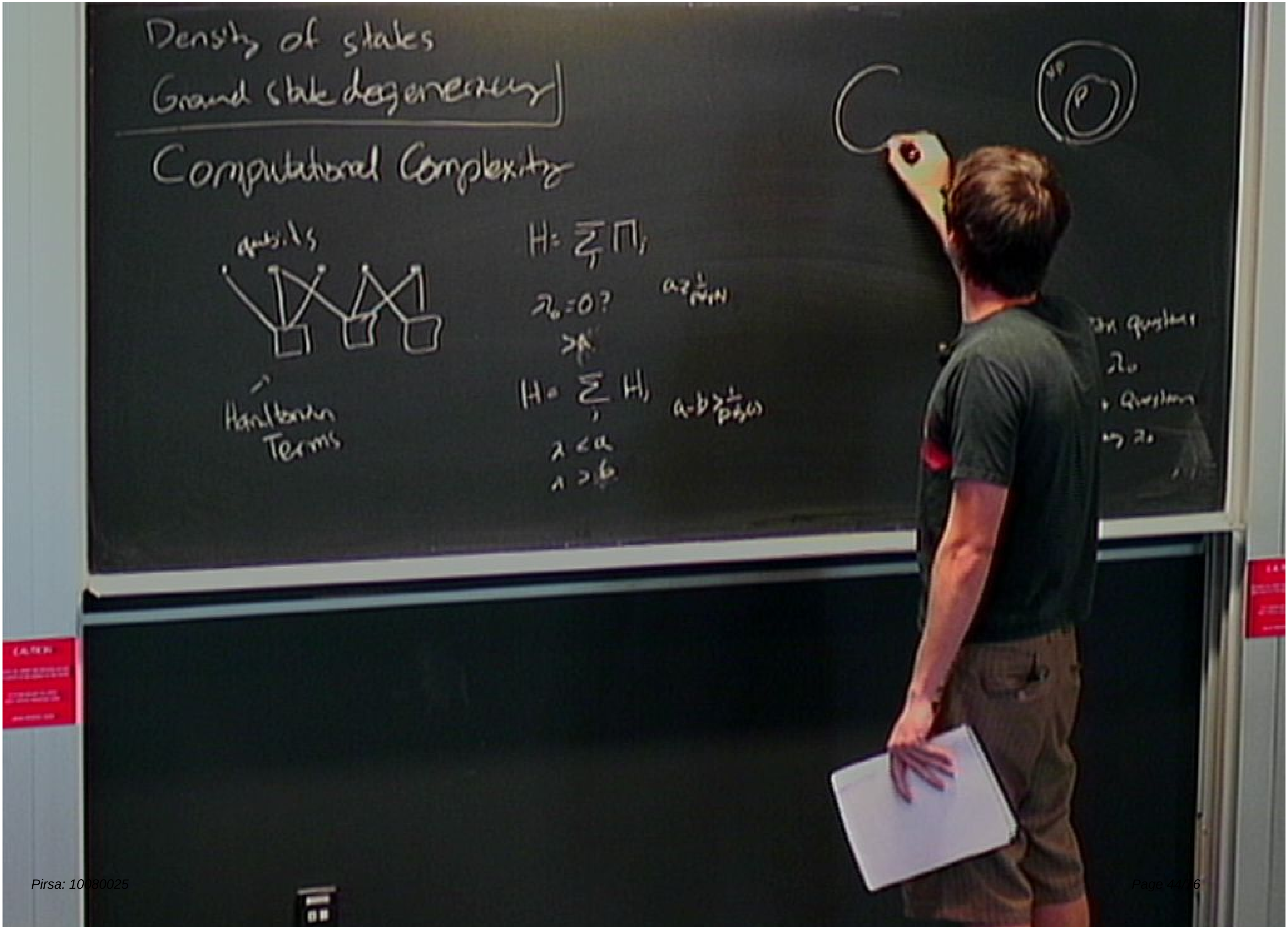

Computational Complexity
qubits
Hamiltonian
Terms

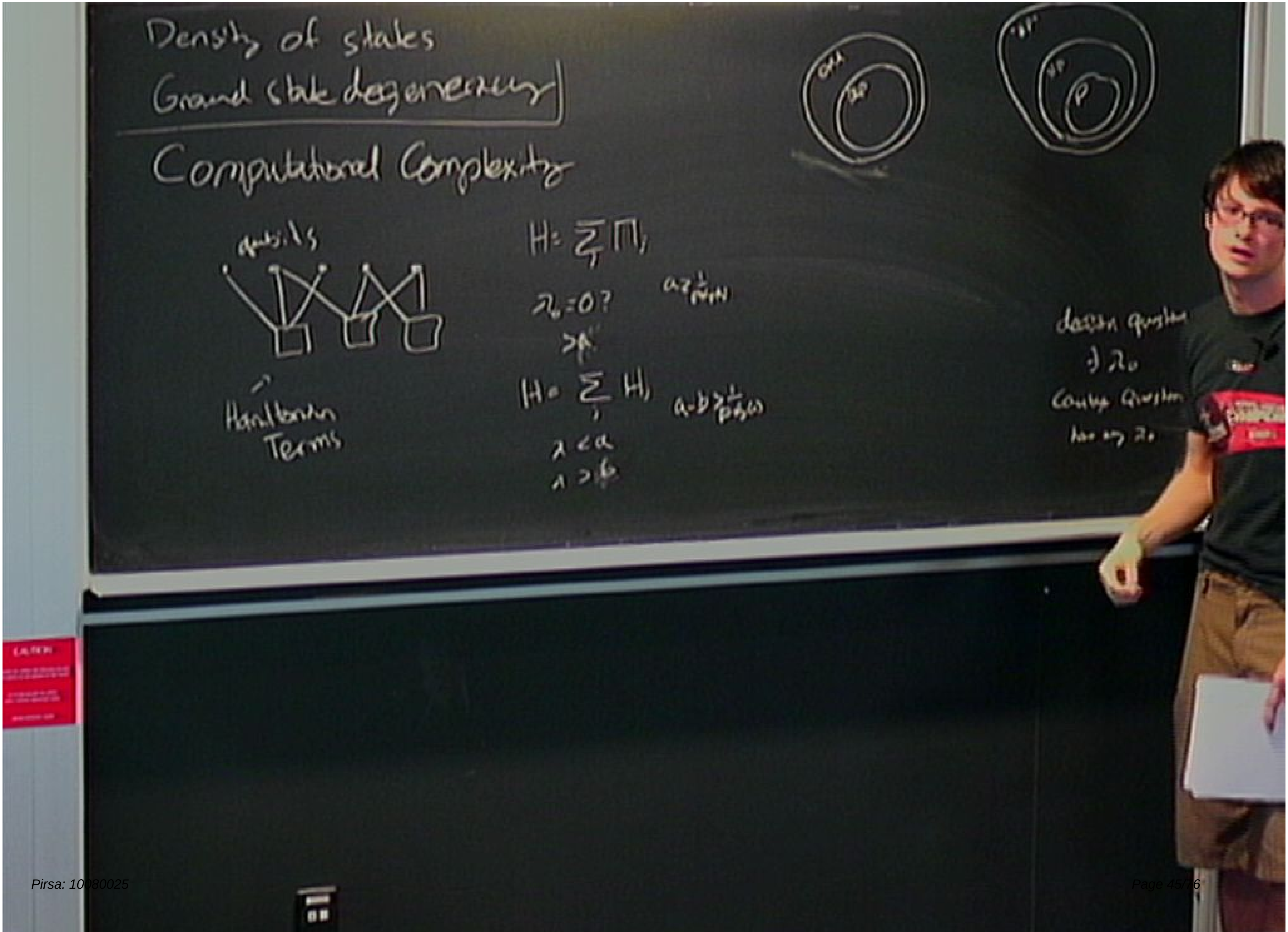

Computational Complexity
qubits
Hamiltonian
Terms
H= Σ_i Π_i
λ_0 = 0?
>a

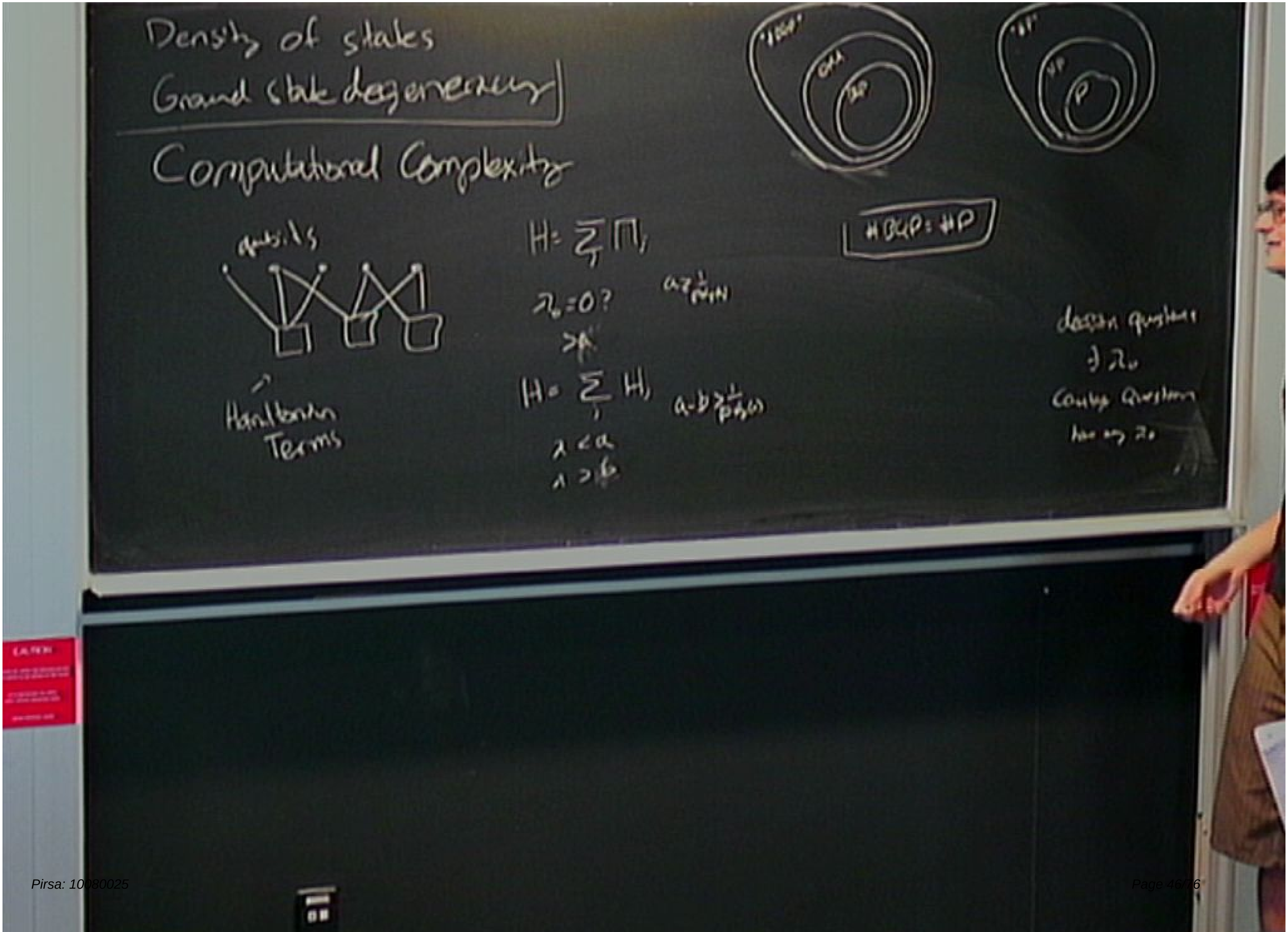

Computational Complexity
qubits
Hamiltonian
Terms


Computational Complexity
qubits
Hamiltonian
Terms

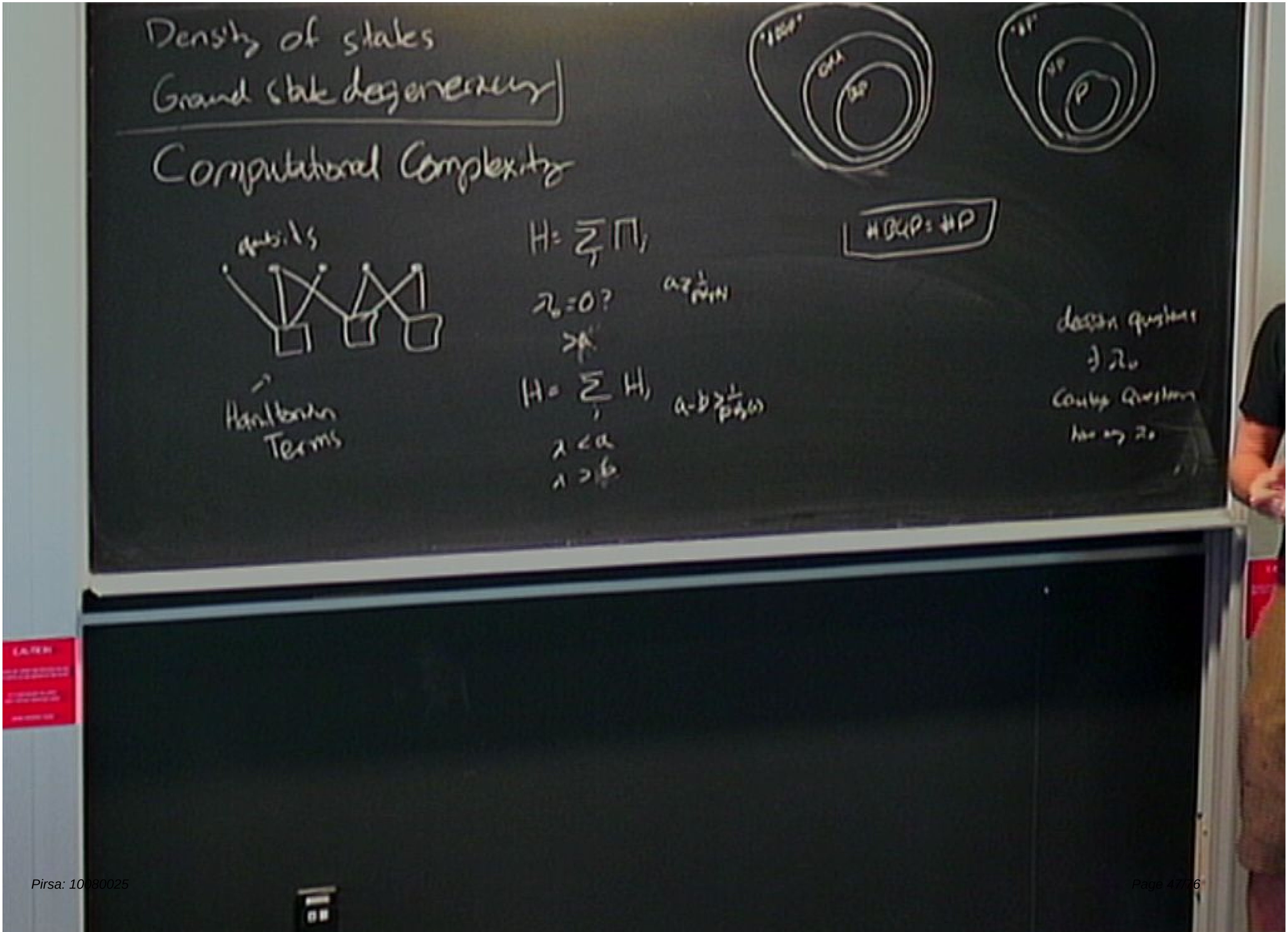

Density of states
Ground state degeneracy
Computational Complexity
qubits
Hamiltonian Terms
$H = \sum_i \Pi_i$
$\lambda_0 = 0$?
$H = \sum_i H_i$
$\lambda < a$
$\lambda > b$

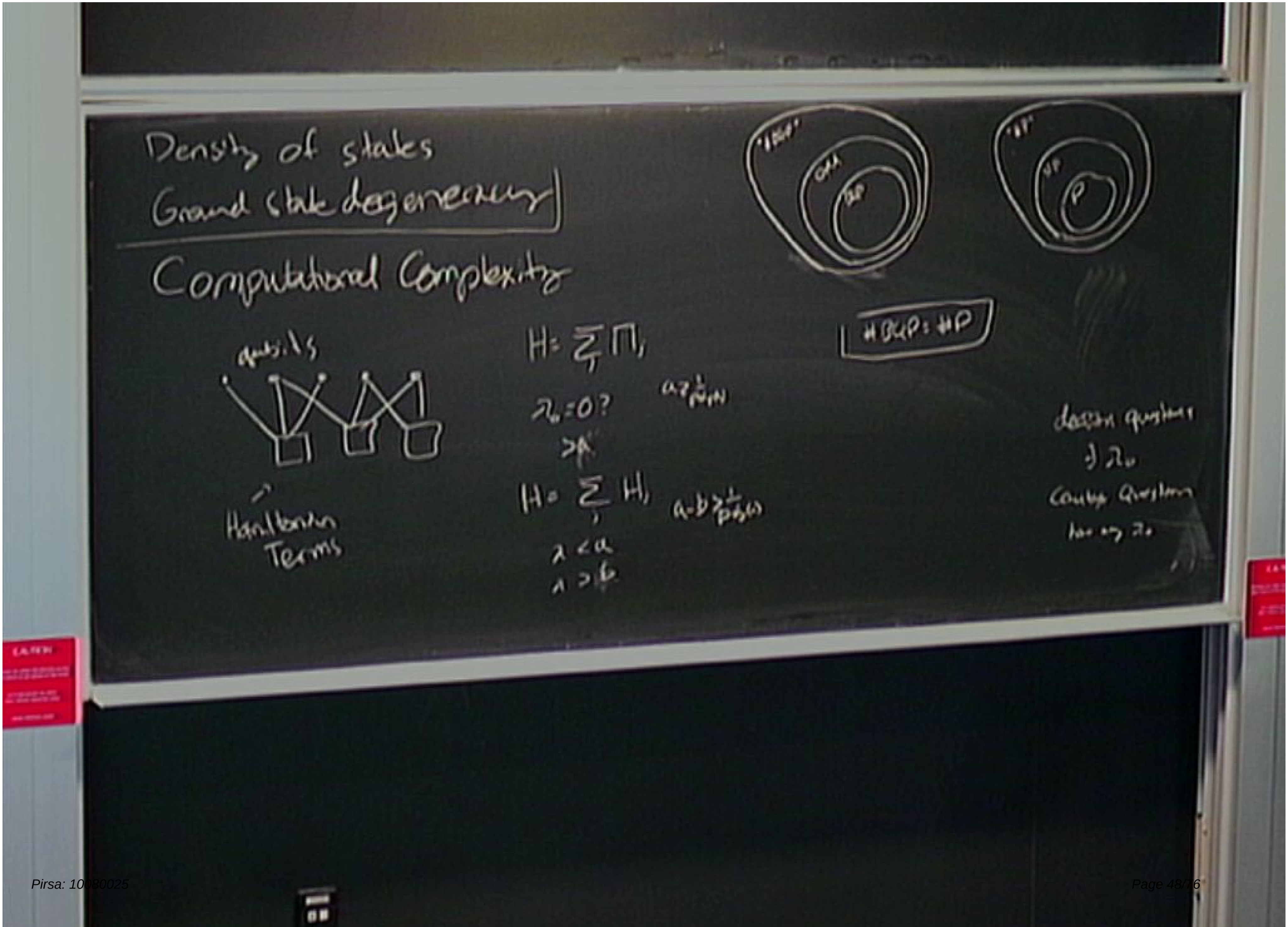

Density of states
Ground state degeneracy
Computational Complexity
qubits
Hamiltonian
Terms
NP
P

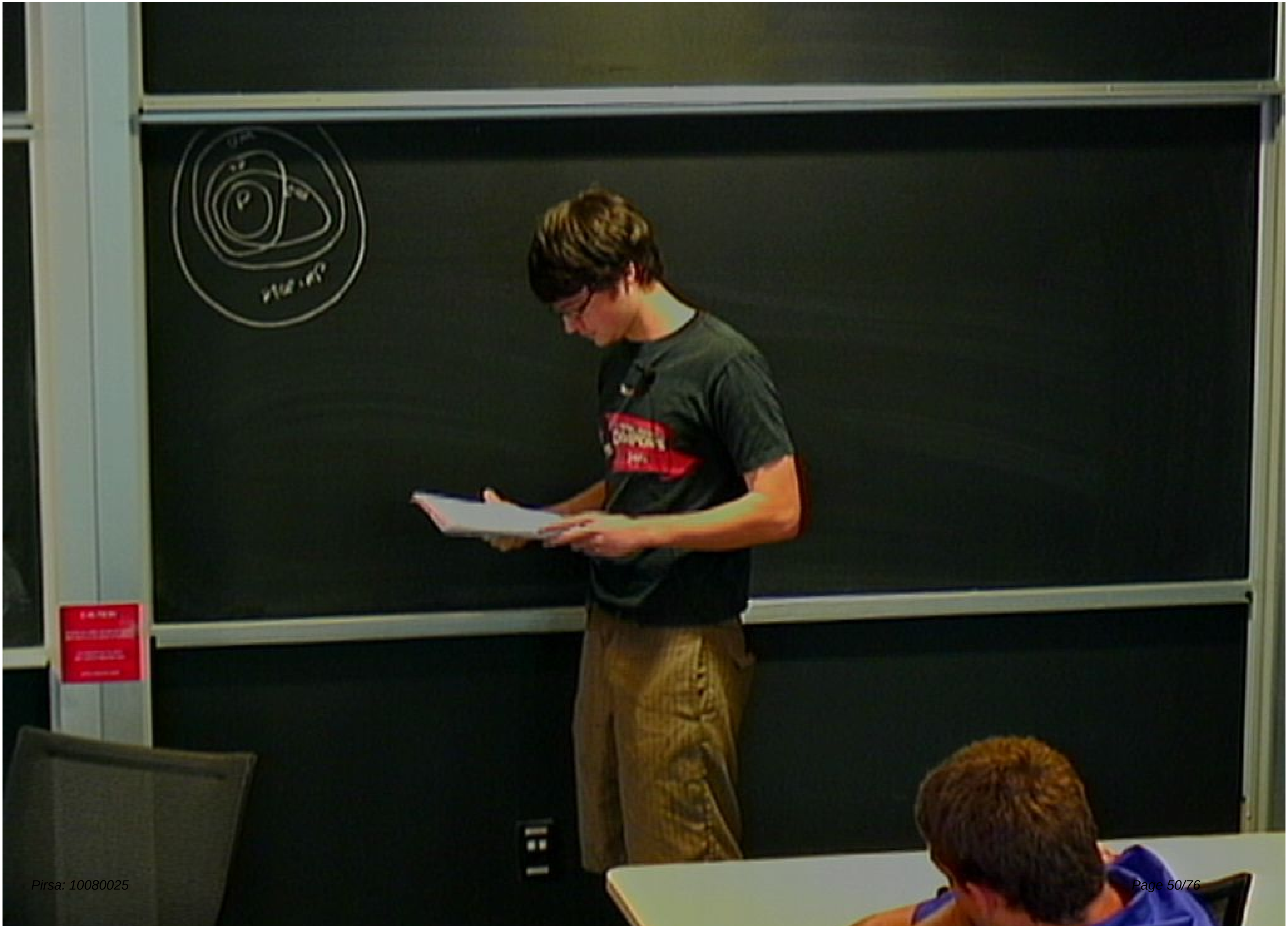

Density of states
Ground state degeneracy
Computational Complexity
qubits
Terms
H = Σ Π
H = Σ H
λ < a

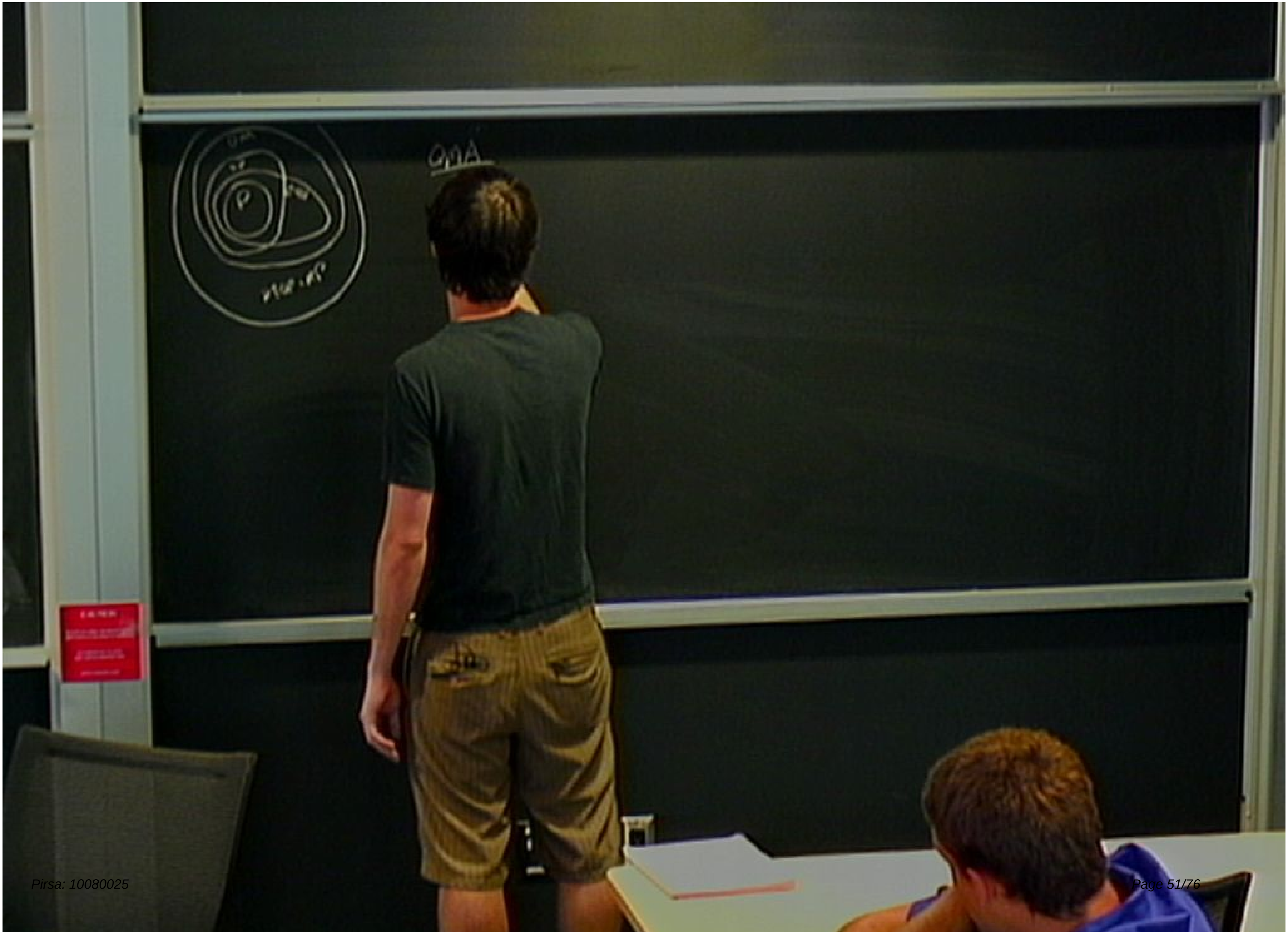


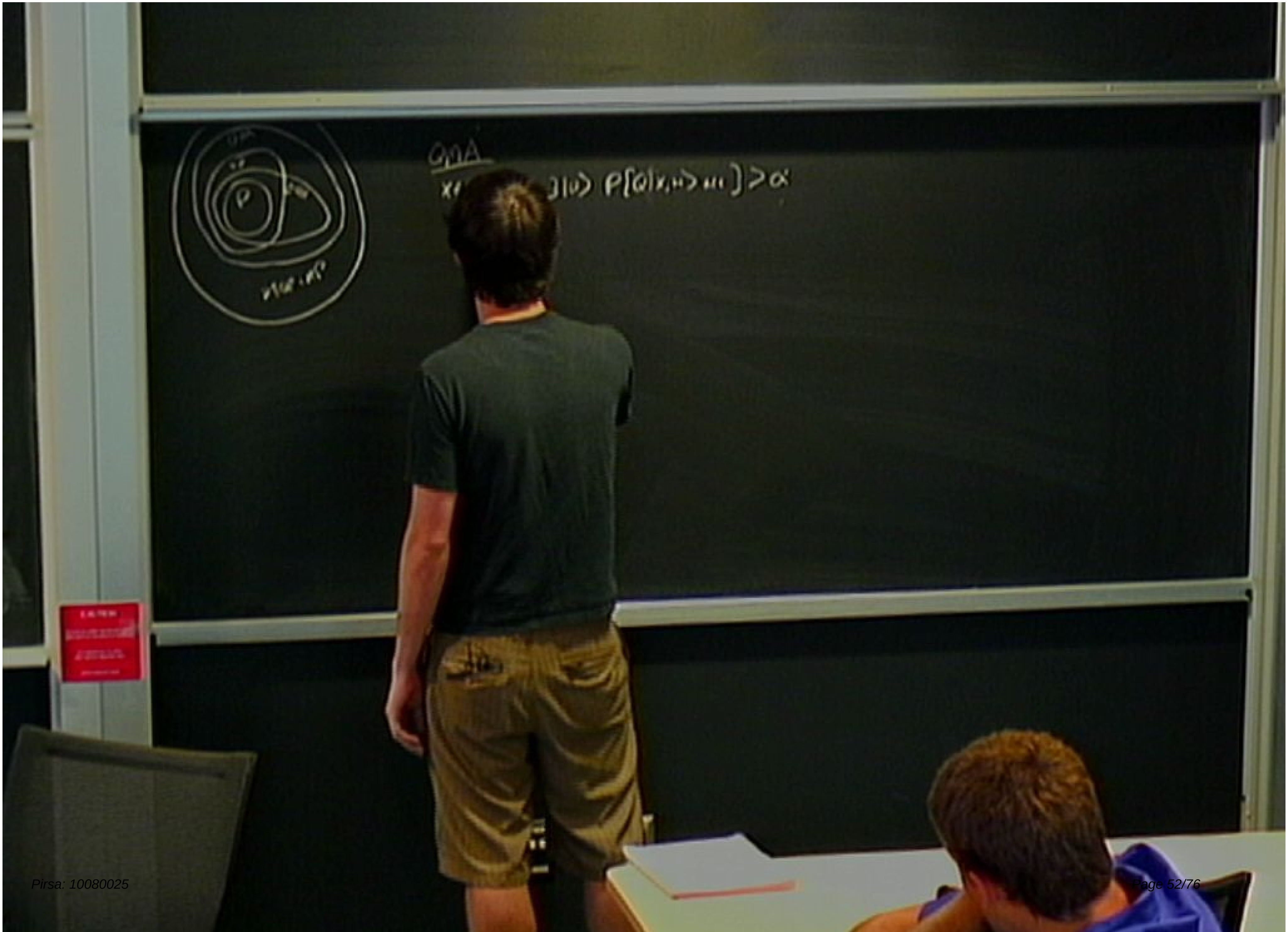
Density of states
Ground state degeneracy
Computational Complexity
qubits
Hamiltonian Terms
#BQP = #P
P

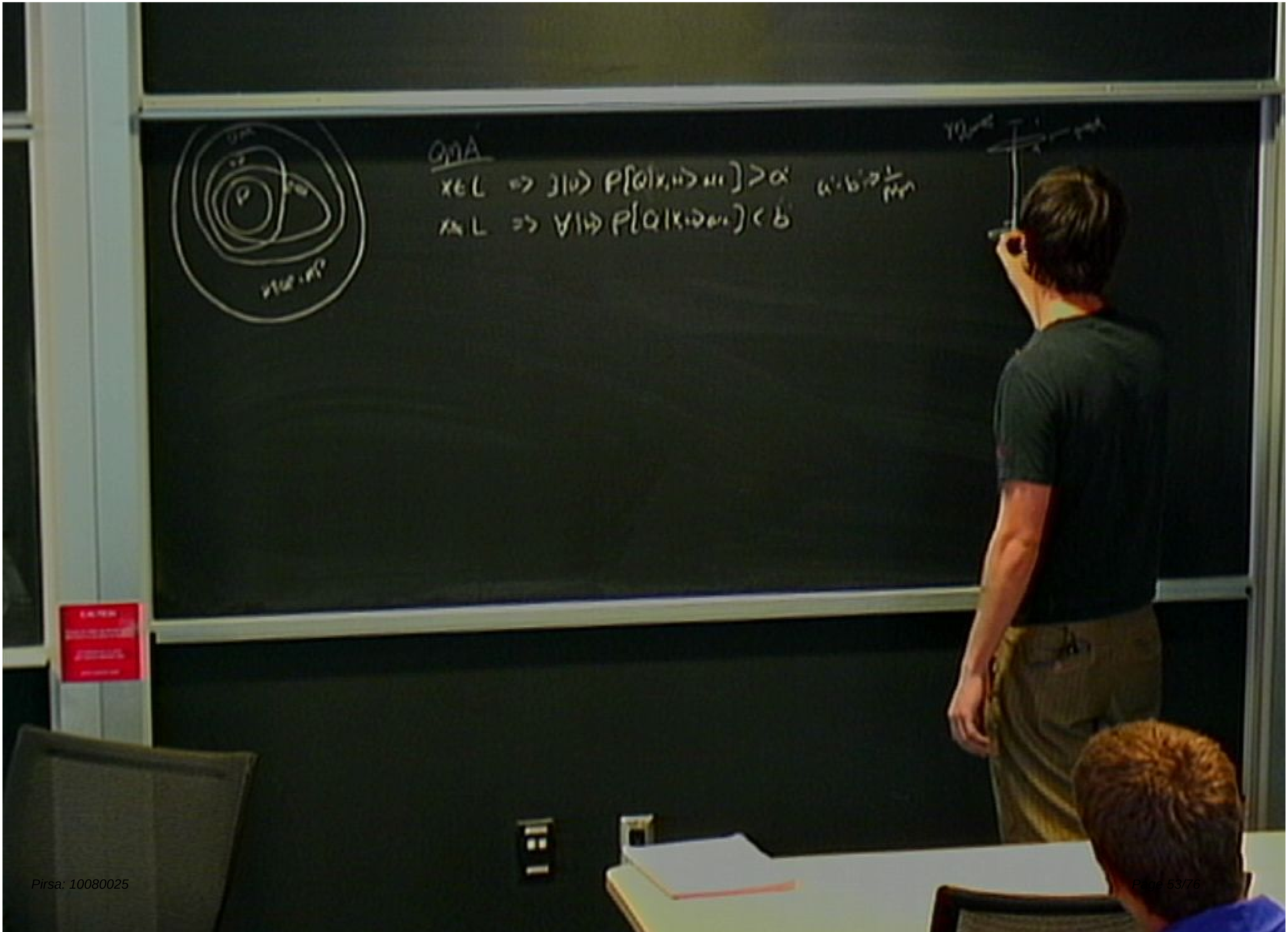

Density of states
Ground state degeneracy
Computational Complexity
qubits
Hamiltonian Terms
#BQP = #P
Count Question

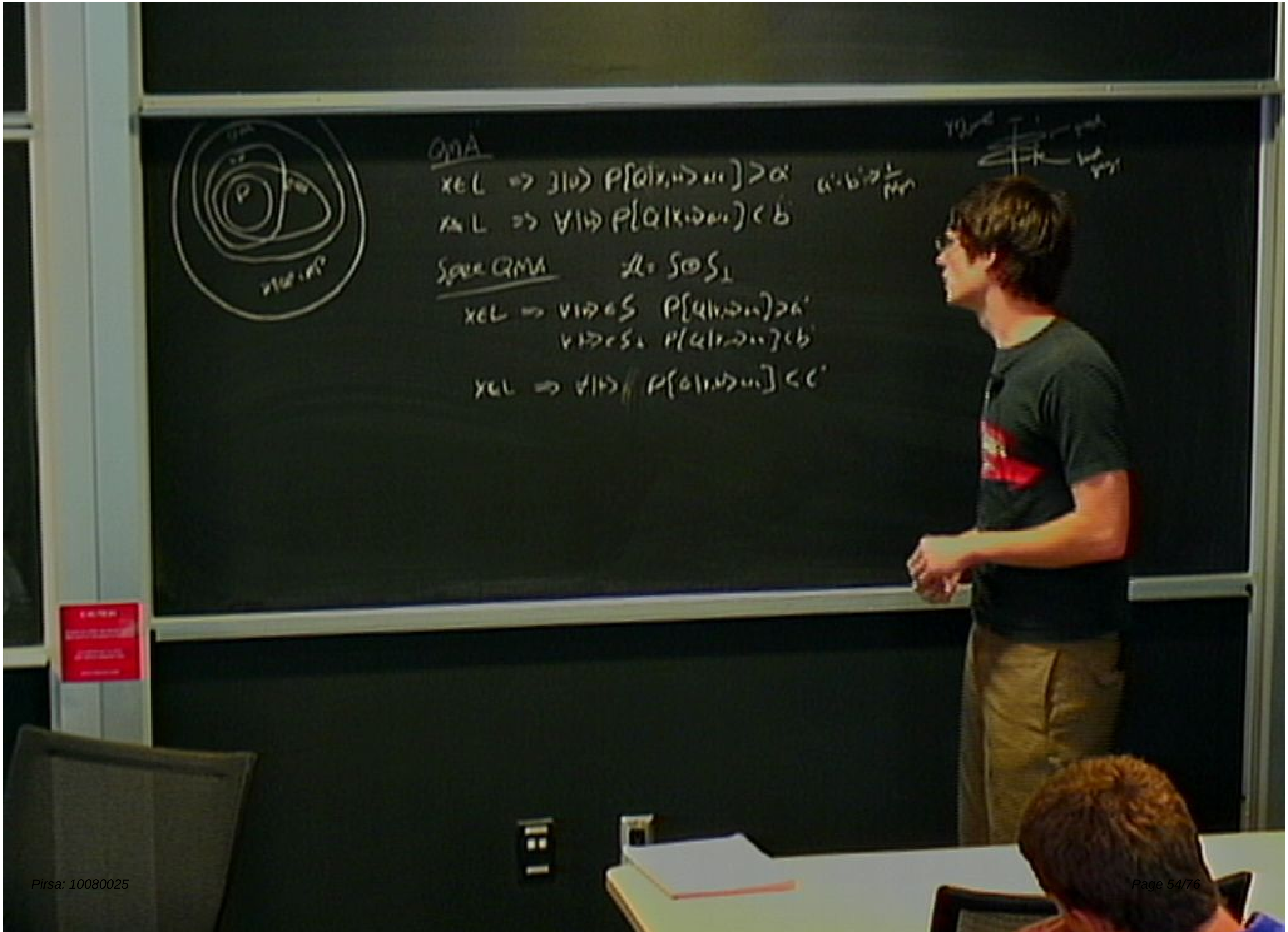

Density of states
Ground state degeneracy
Computational Complexity
qubits
Hamiltonian Terms
#BQP = #P
decision questions
Counting Questions

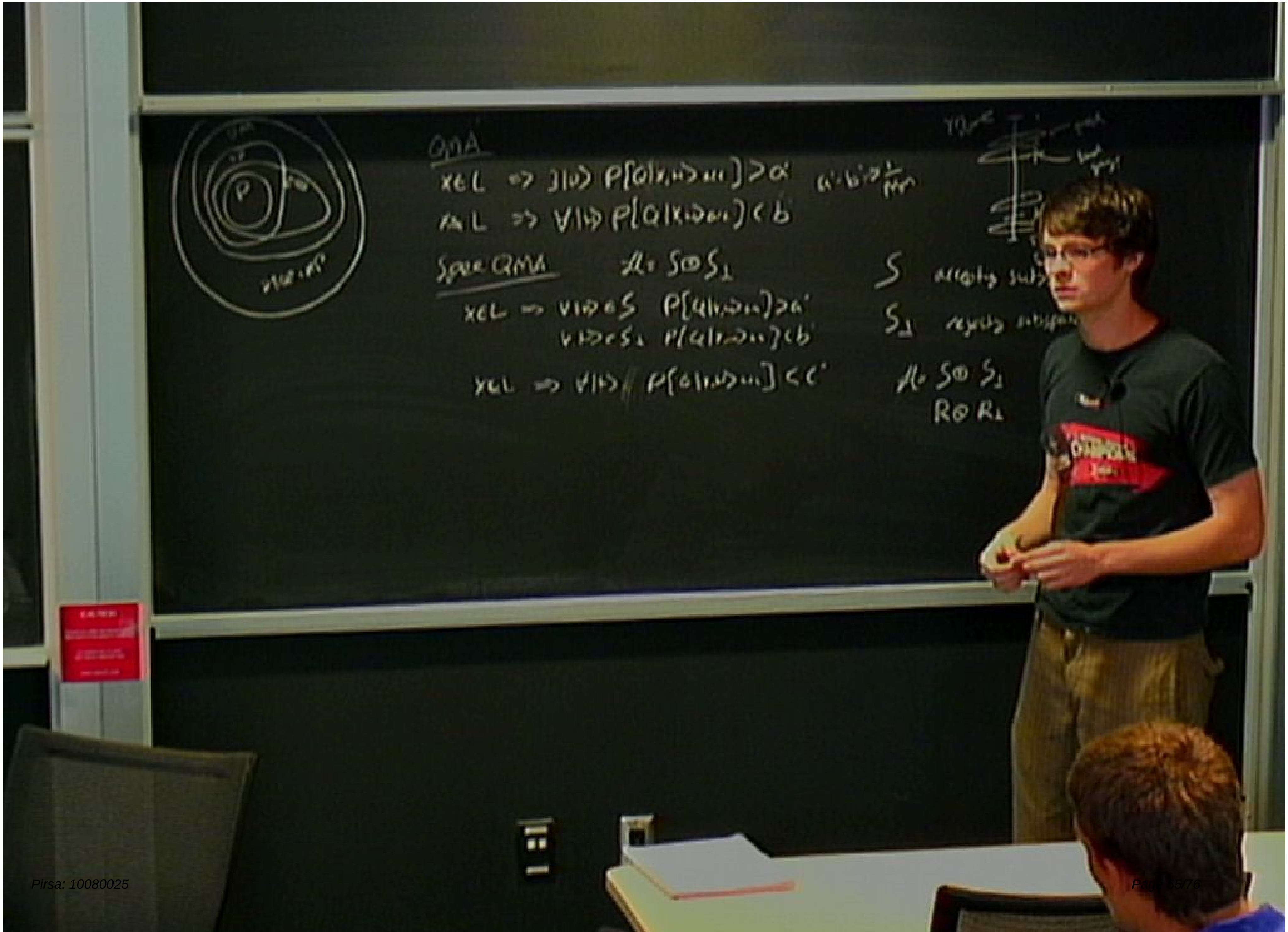


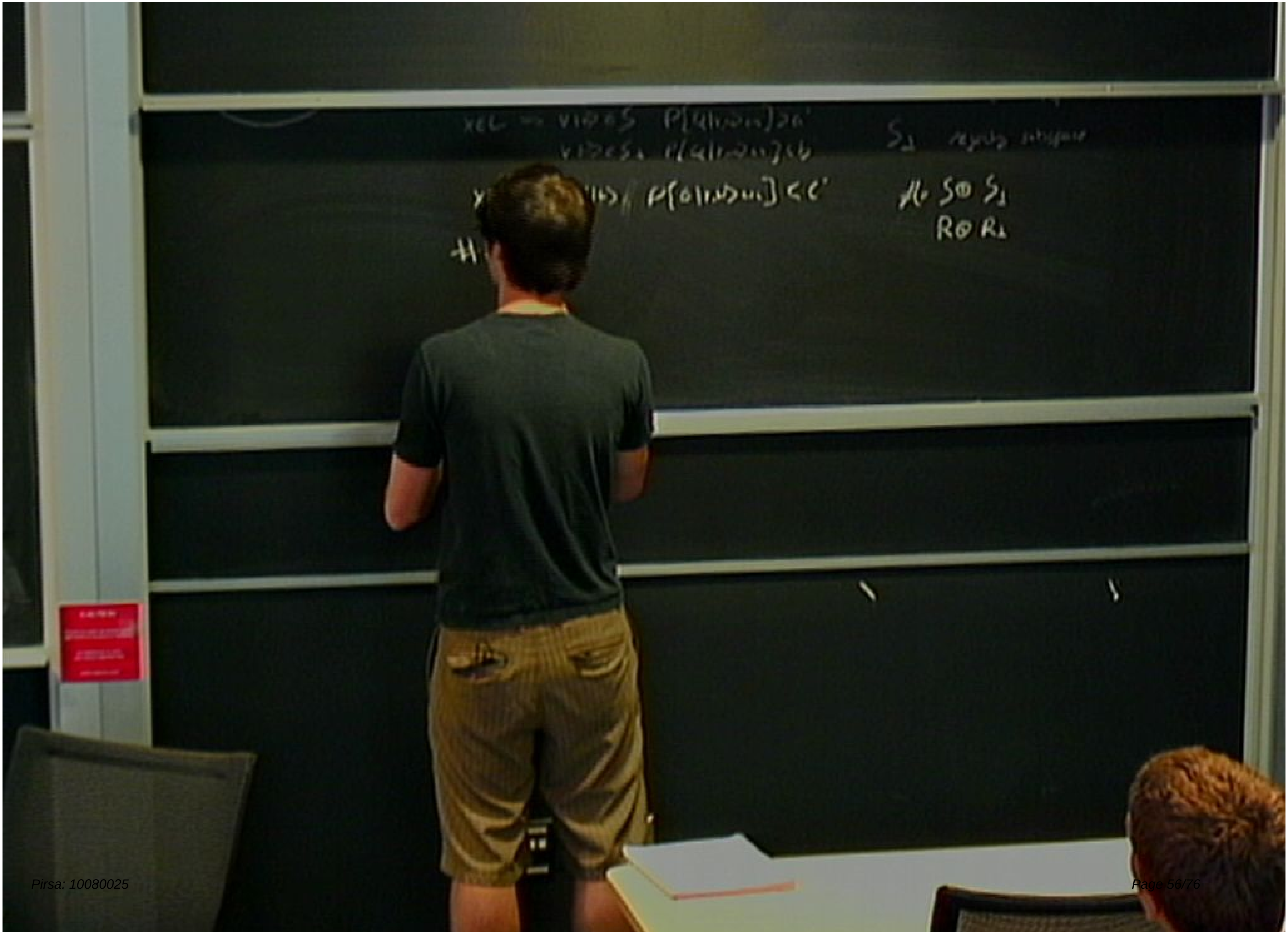

QMA
P

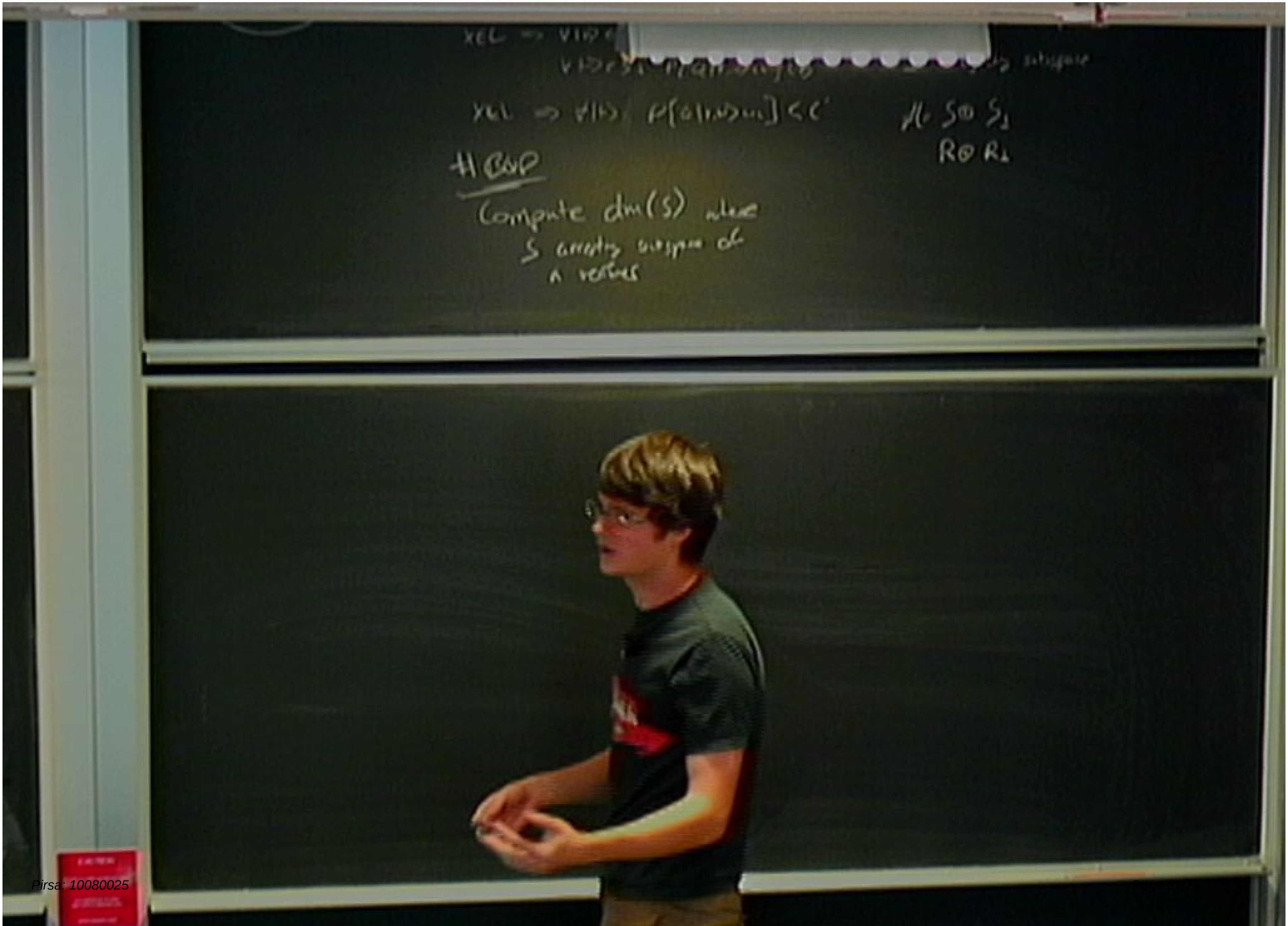

QMA


QMA


QMA
Sparse QMA
P


QMA





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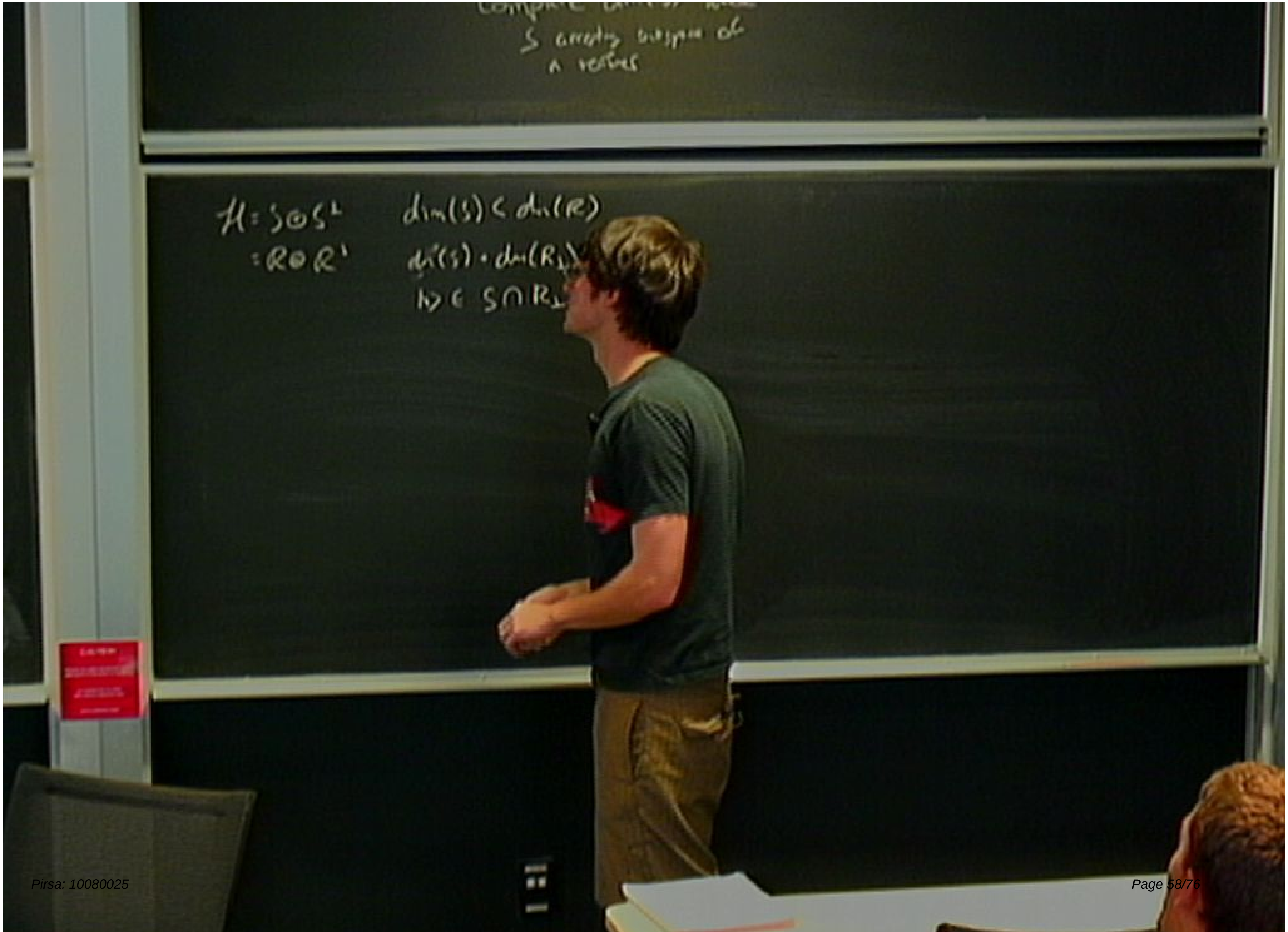
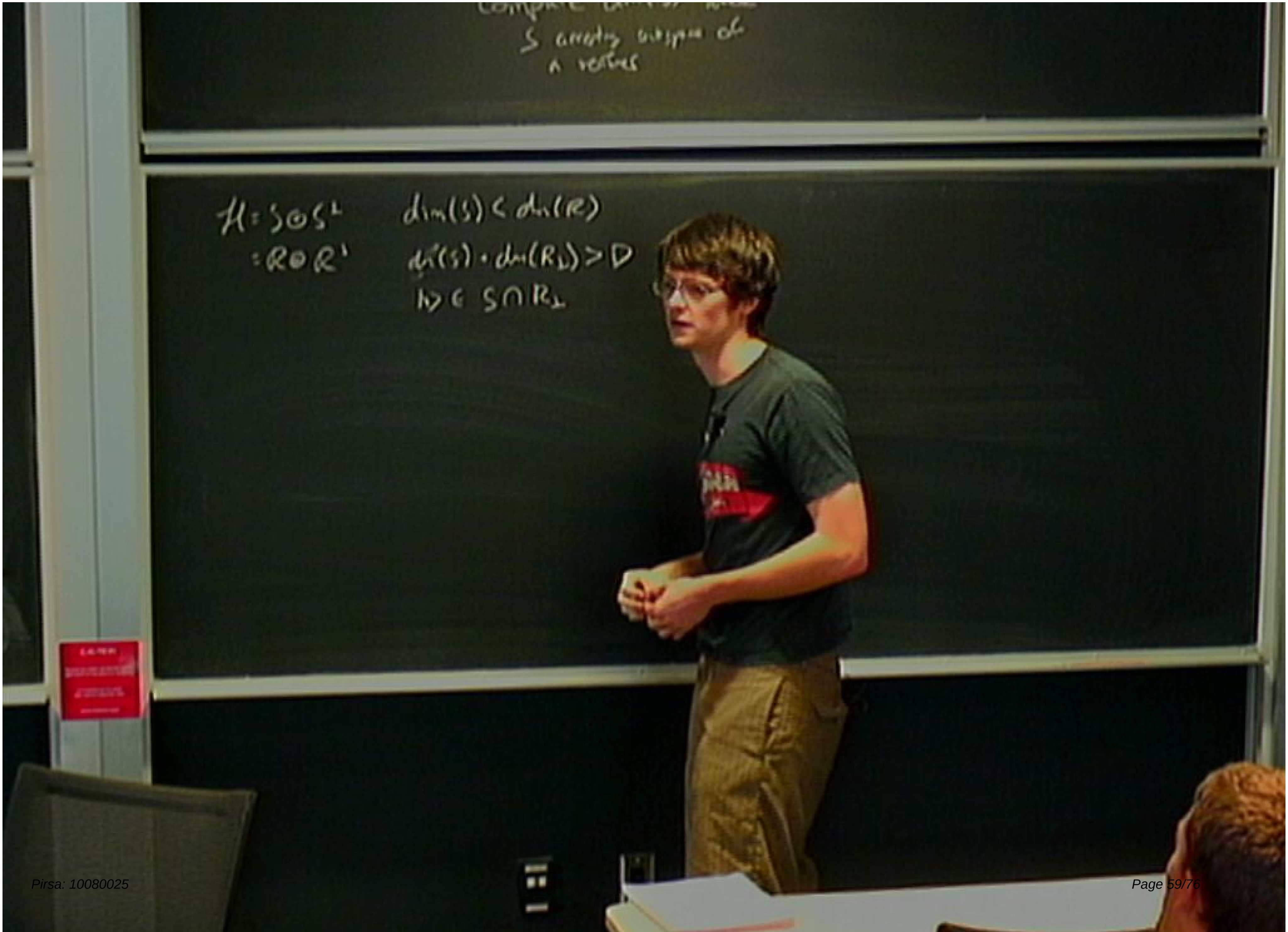
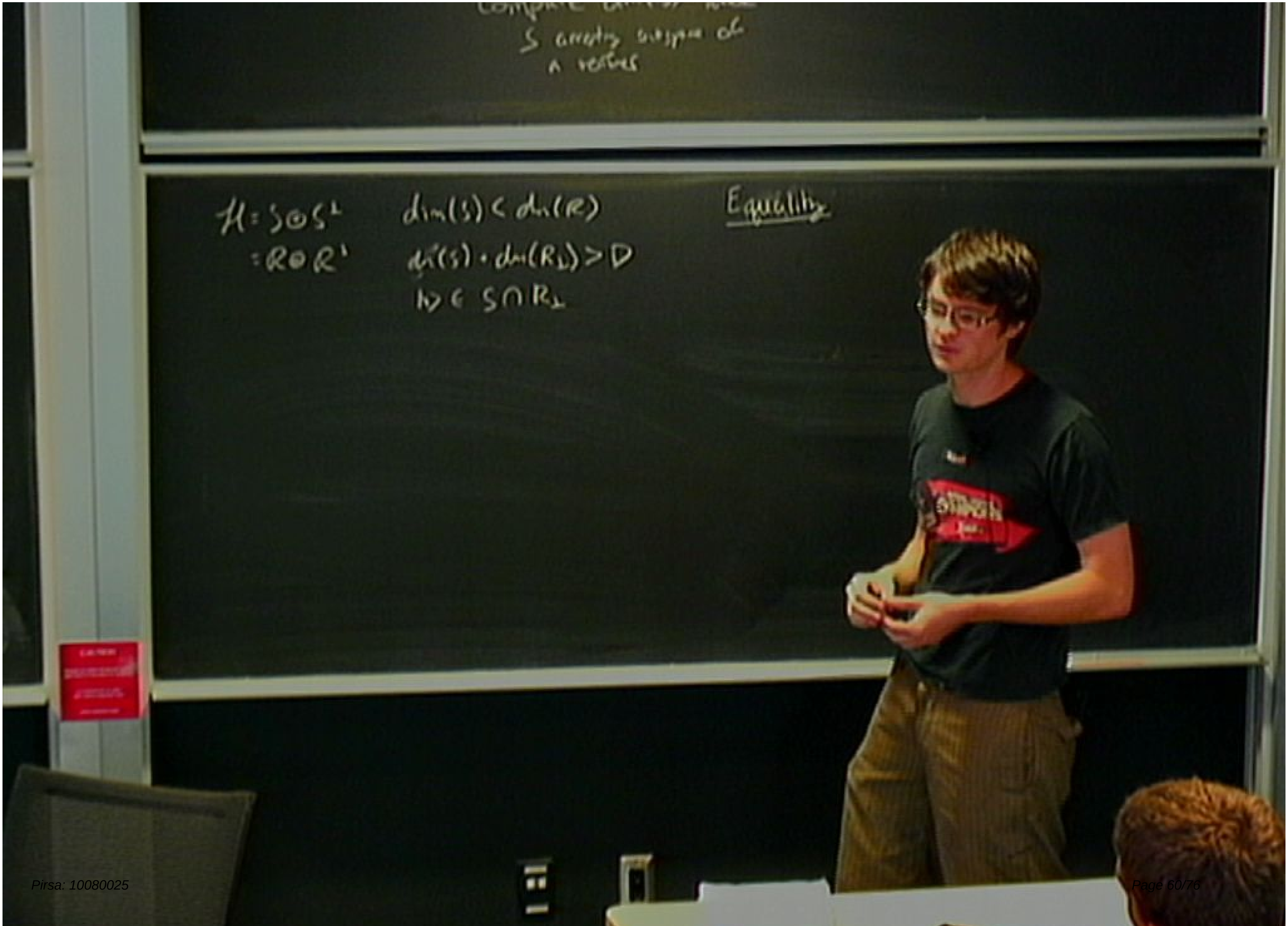
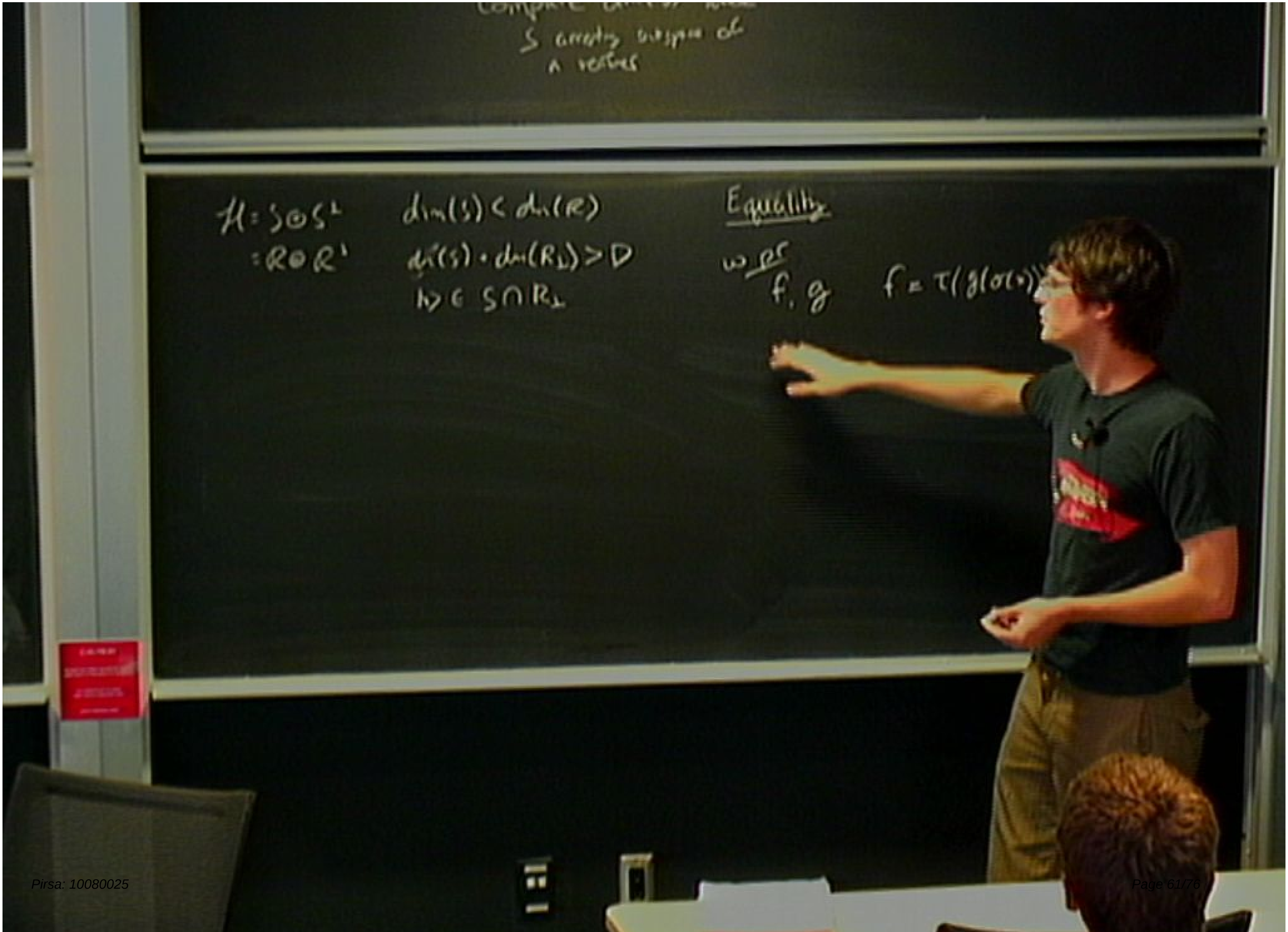
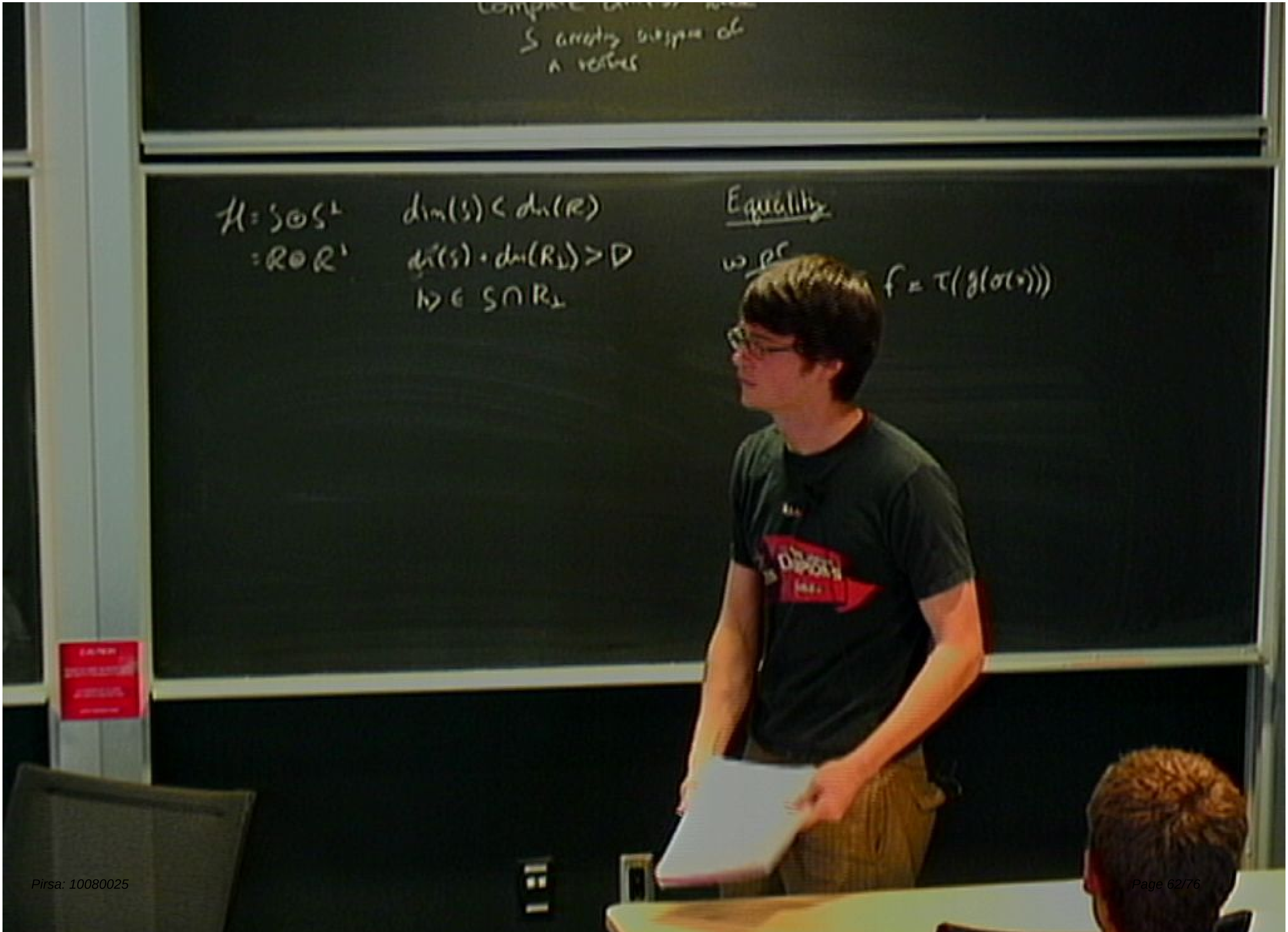
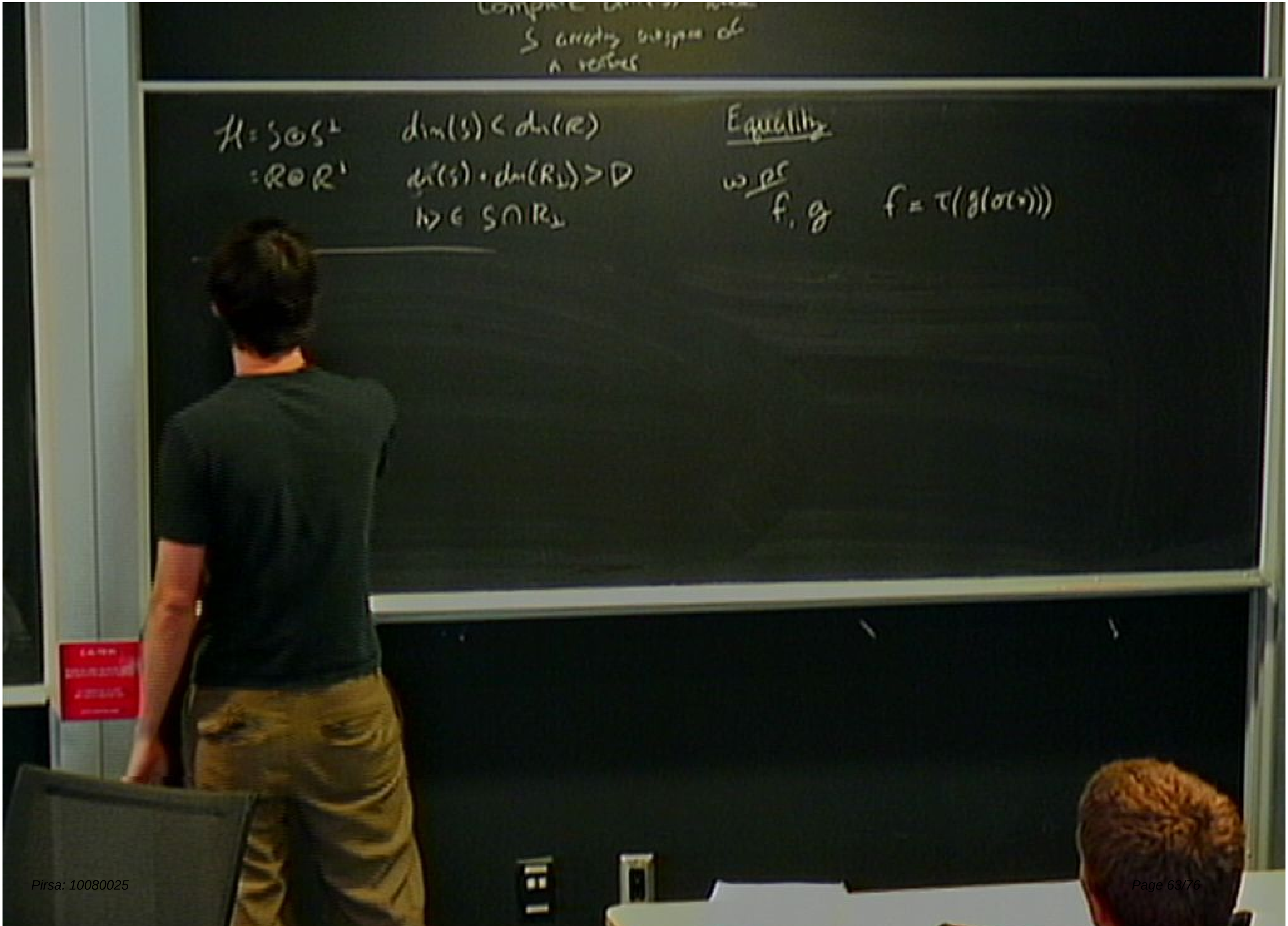

S arresting subspace of
n vertices
$\mathcal{H} = S \oplus S^\perp$
$= R \oplus R^\perp$
$\dim(S) < \dim(R)$
$\dim(S) + \dim(R_\perp)$
$|\psi\rangle \in S \cap R_\perp$

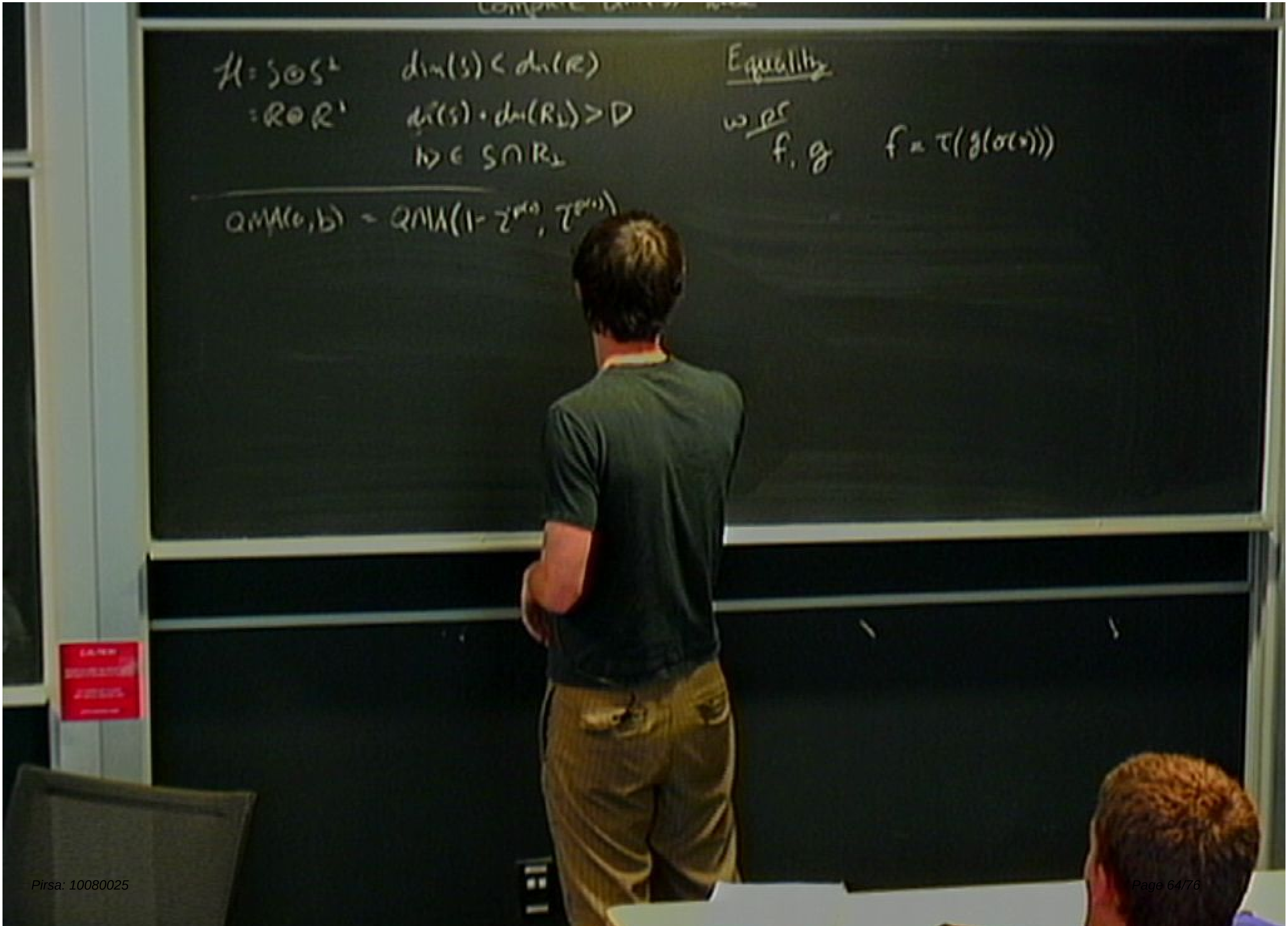

H = S ⊕ S⊥
= R ⊕ R⊥
dim(S) < dim(R)
dim(S) + dim(R⊥) > D
|ψ⟩ ∈ S ∩ R⊥

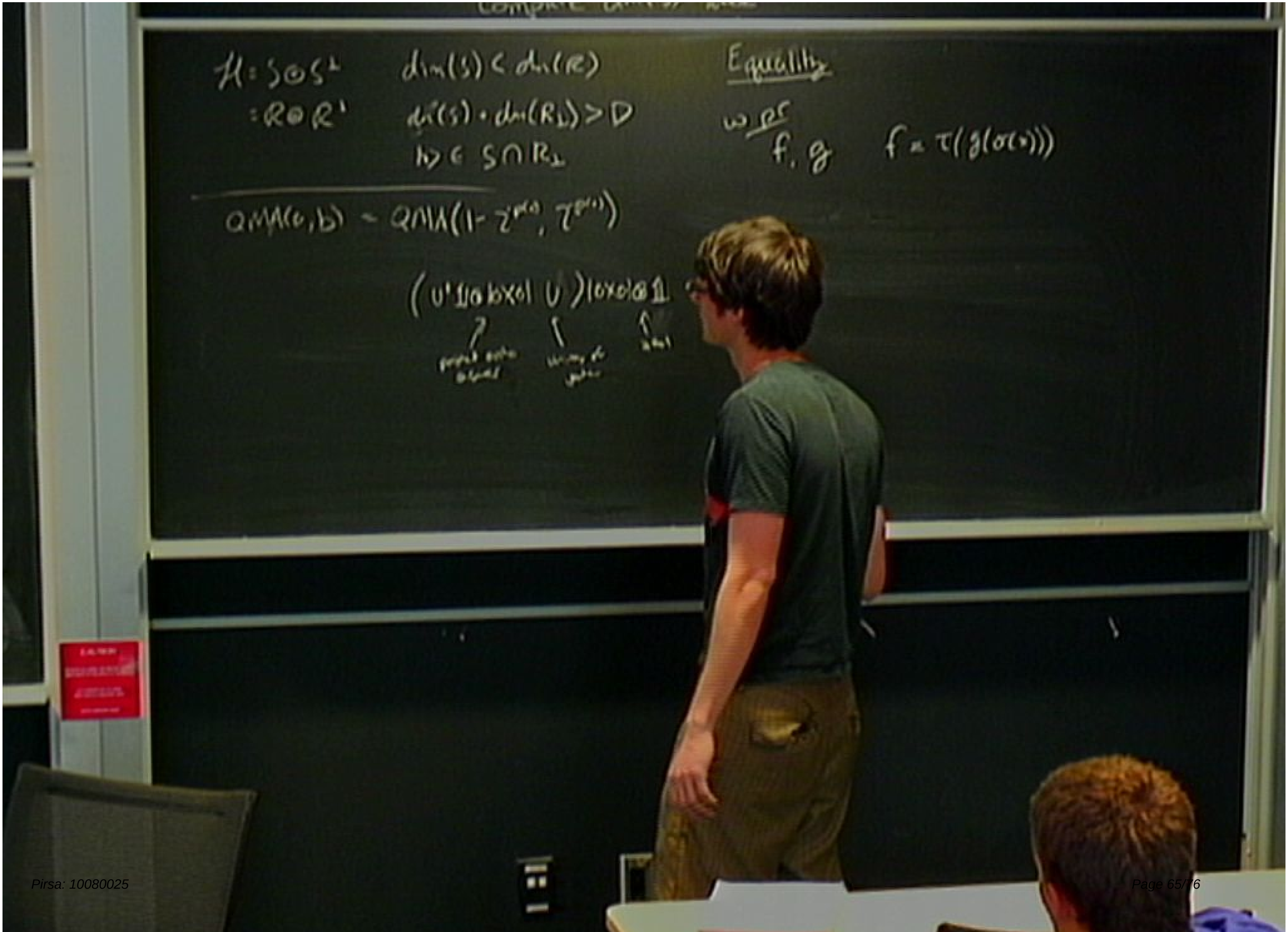

H = S ⊕ S^⊥
= R ⊕ R^⊥
dim(S) < dim(R)
dim(S) + dim(R⊥) > D
|ψ⟩ ∈ S ∩ R⊥
Equality

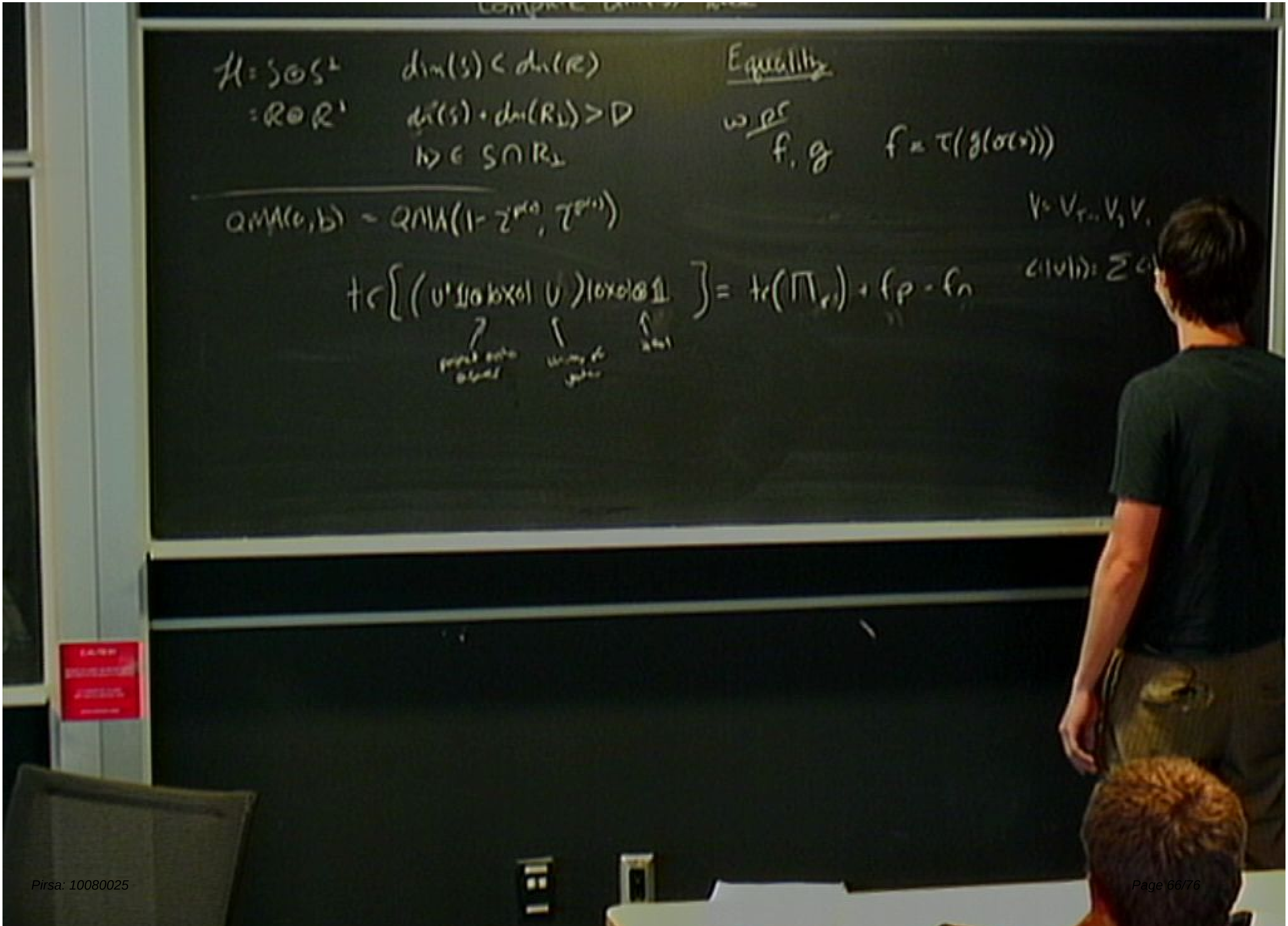

H = S ⊕ S⊥
= R ⊕ R⊥
dim(S) < dim(R)
dim(S) + dim(R⊥) > D
|ψ⟩ ∈ S ∩ R⊥
Equality
w. pr
f, g

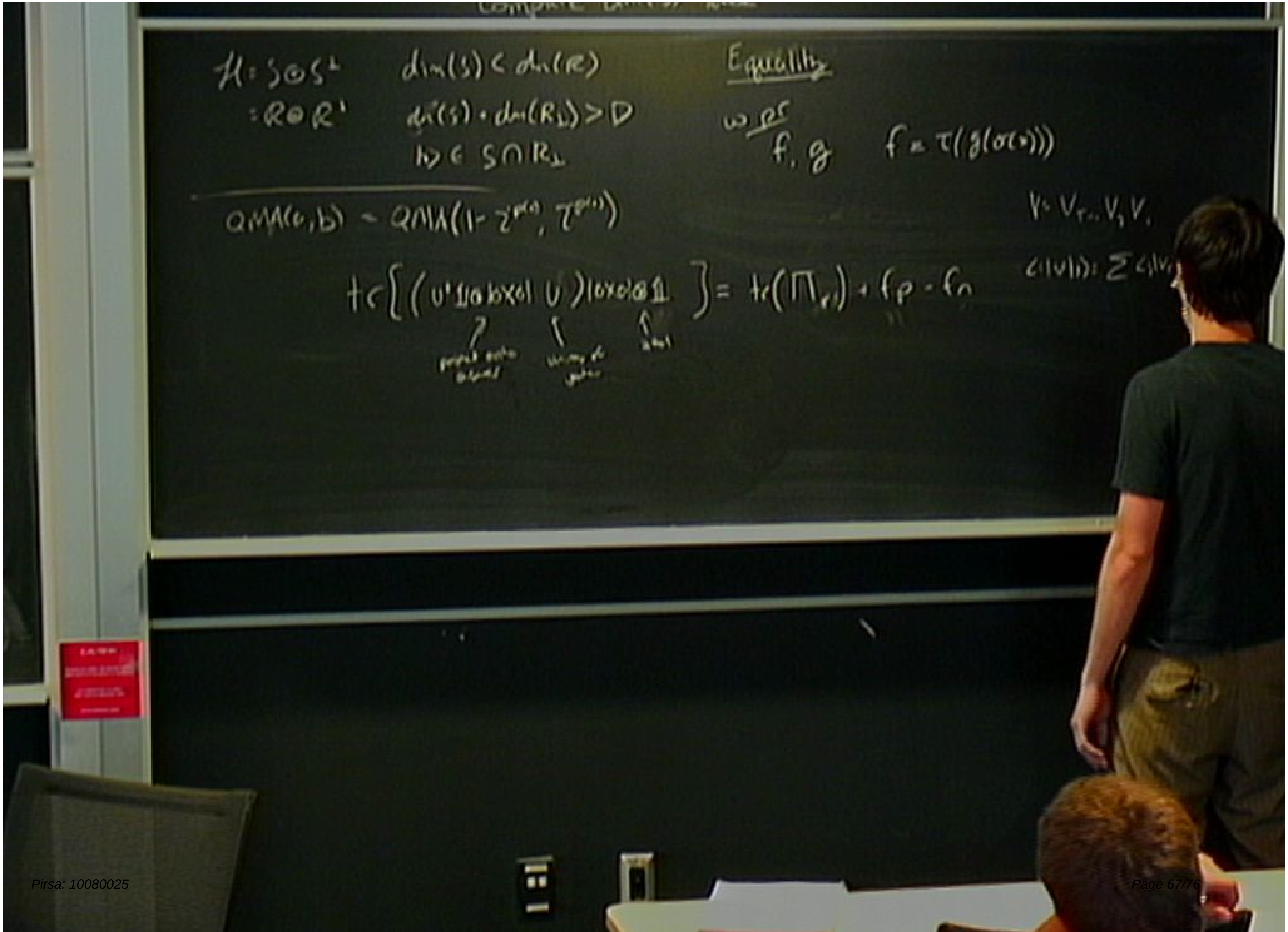

dim(S) < dim(R)
Equality

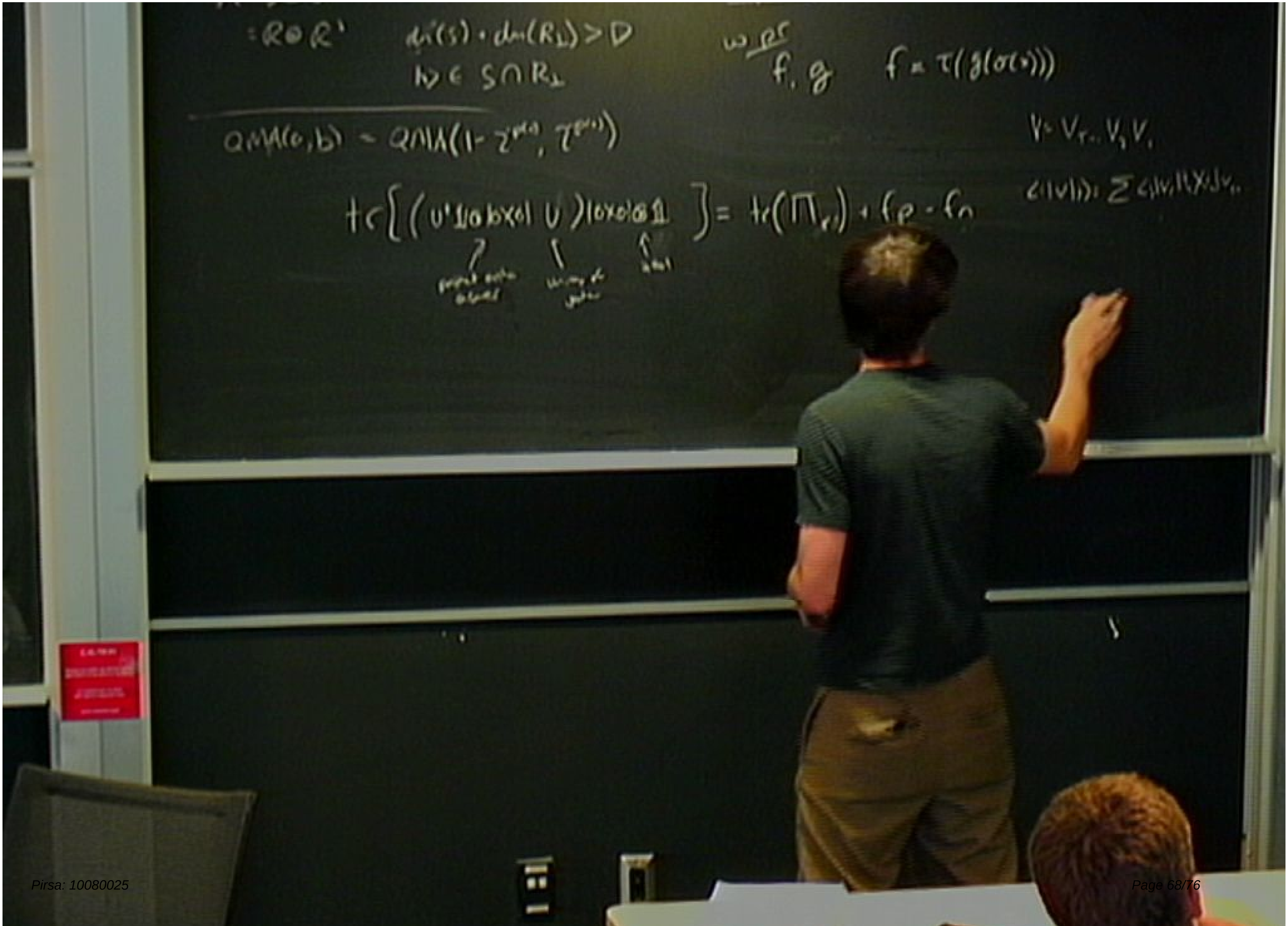

dim(S) < dim(R)
Equality
f, g
f = τ(g(σ(x)))

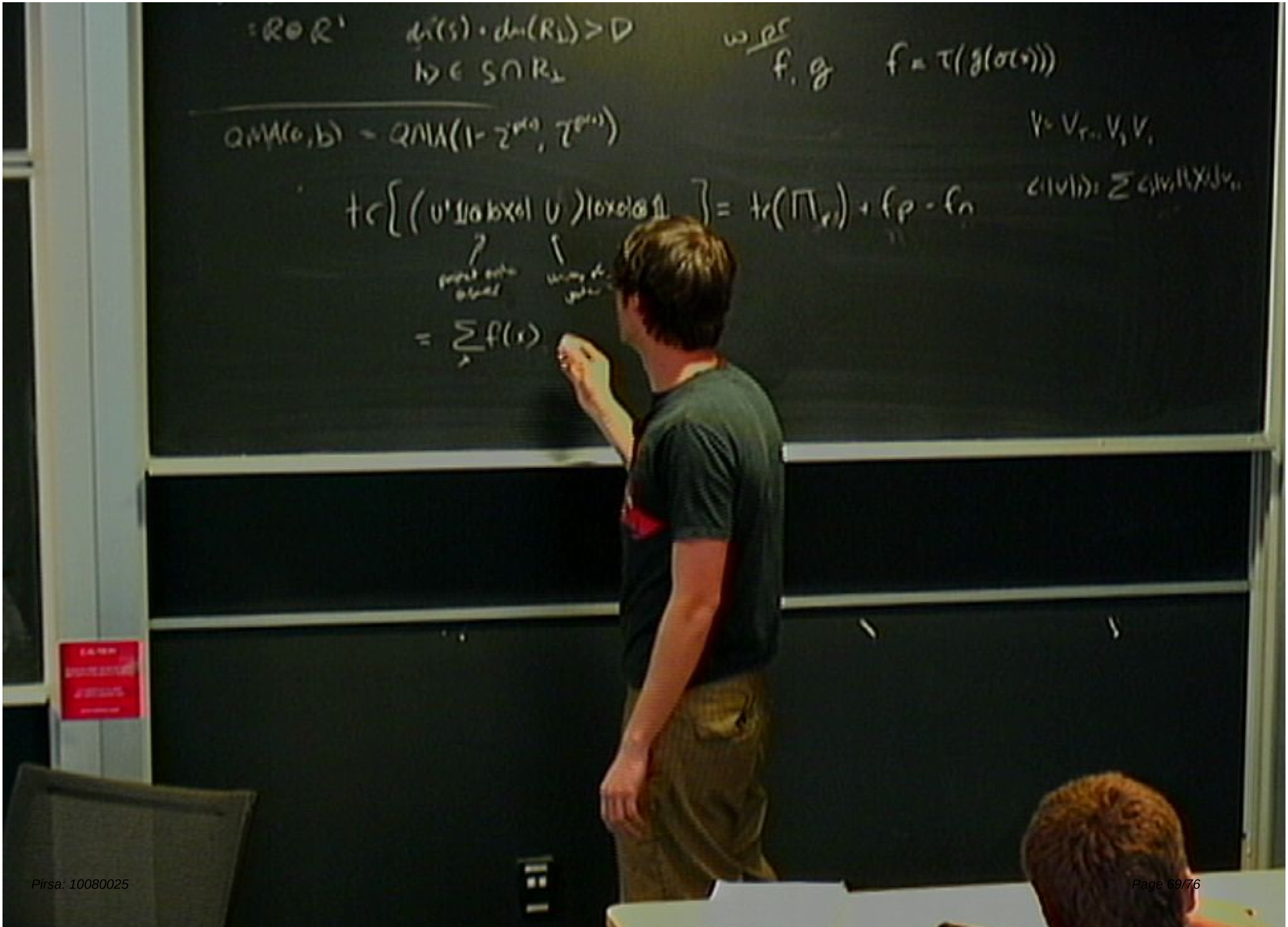

dim(S) < dim(R)
Equality
f, g

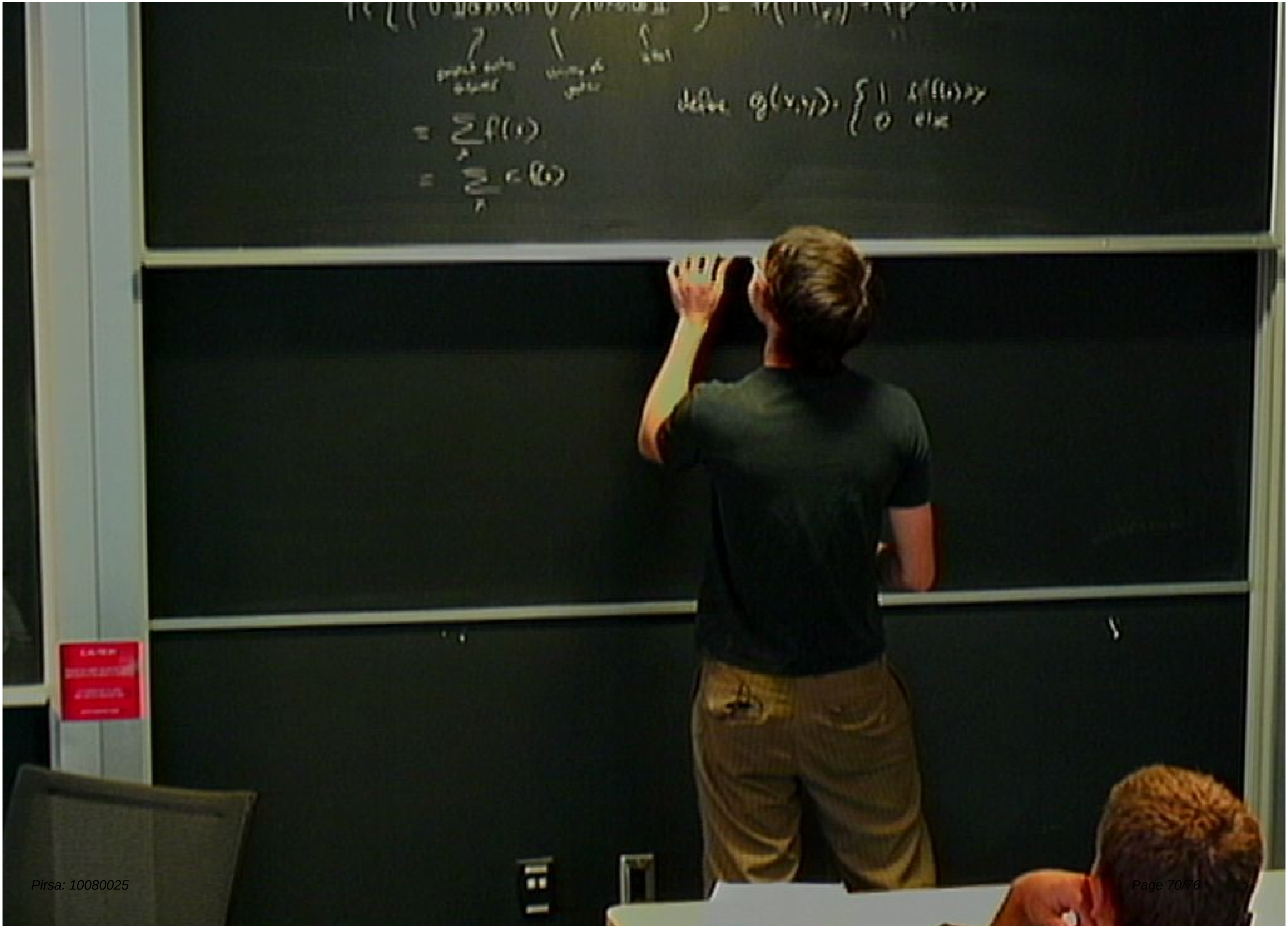

Equality

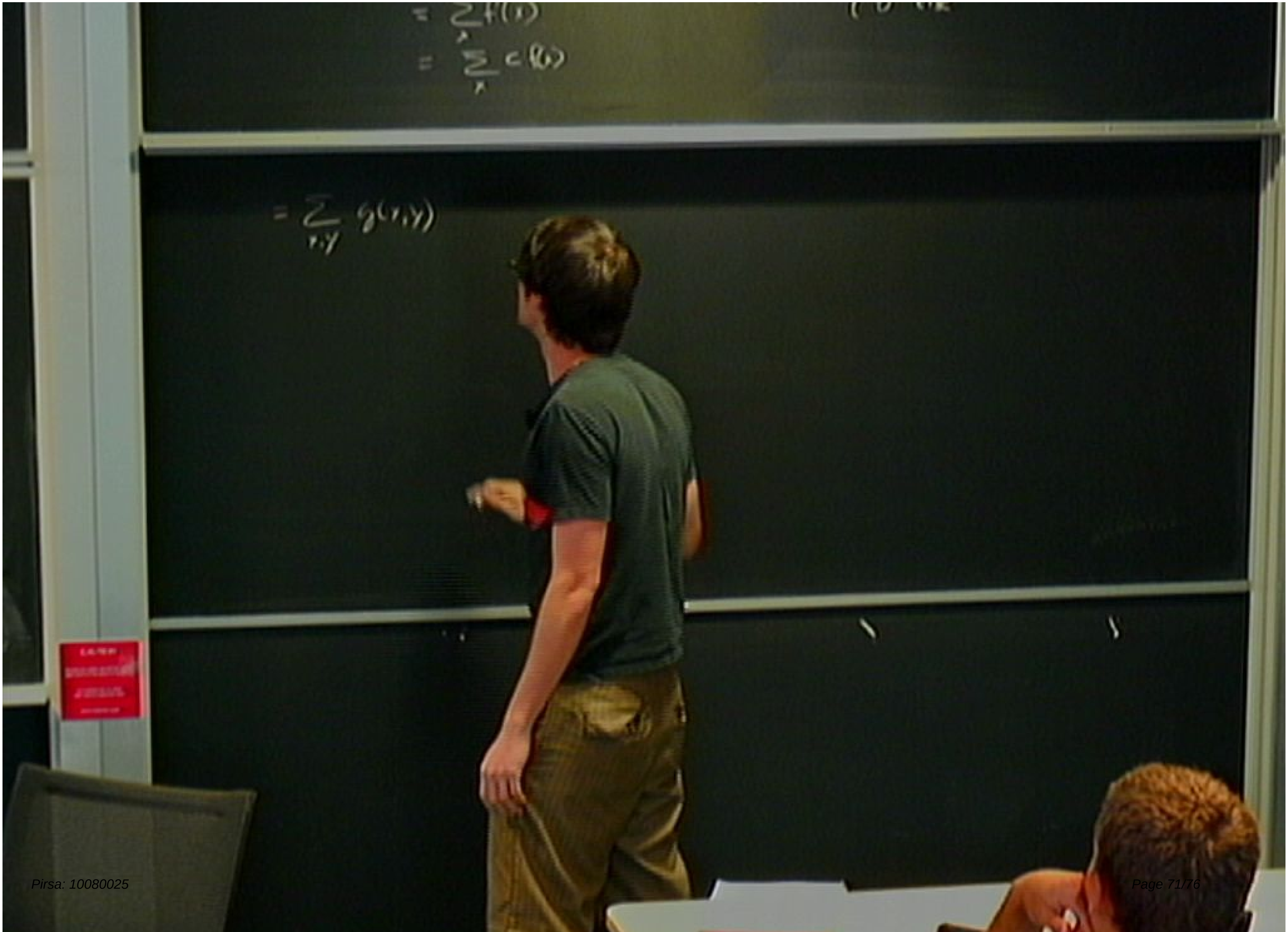

dim(S) < dim(R)
Equality
f = τ(g(σ(x)))

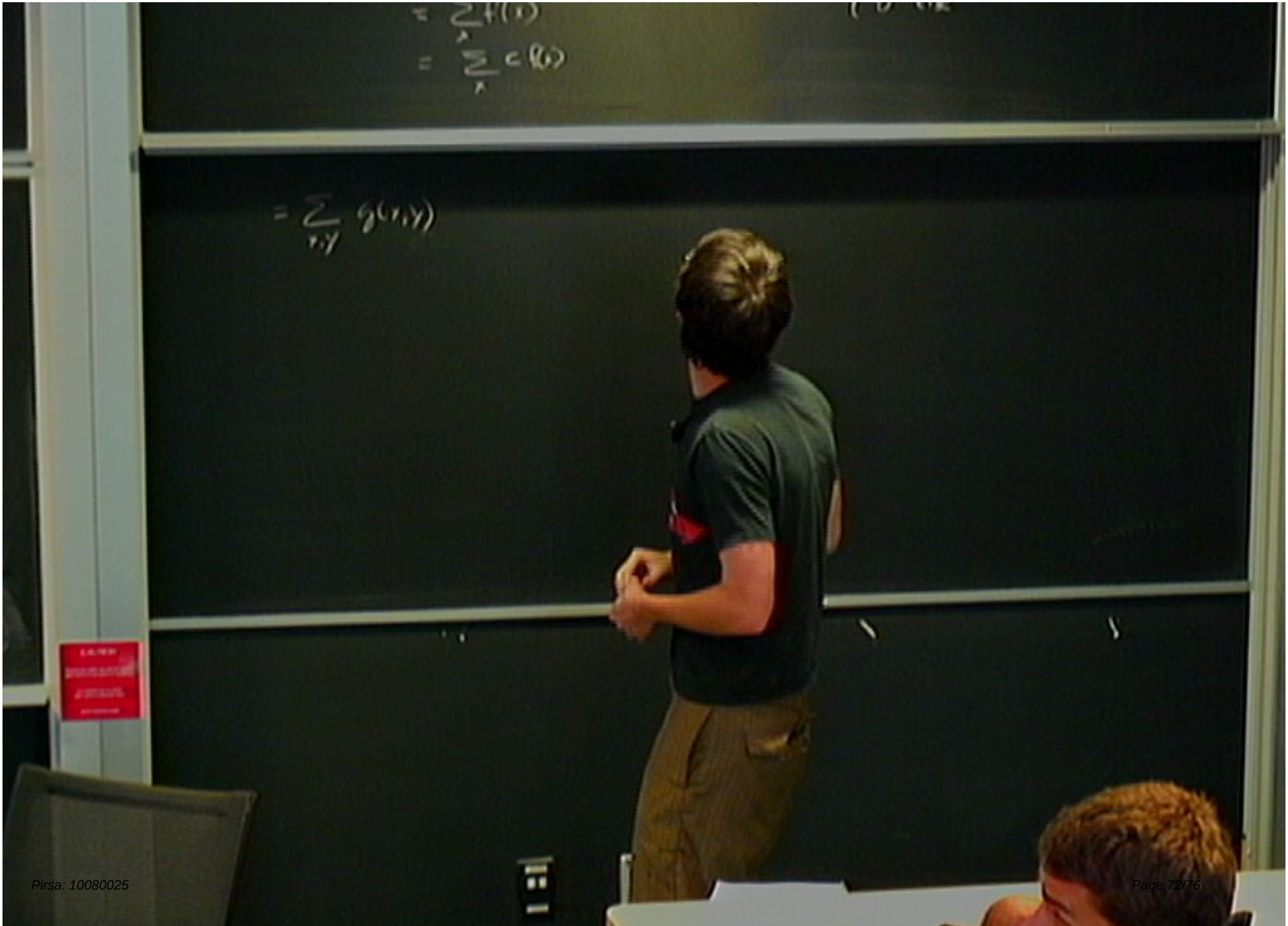

dim(S) < dim(R)
Equality
f, g

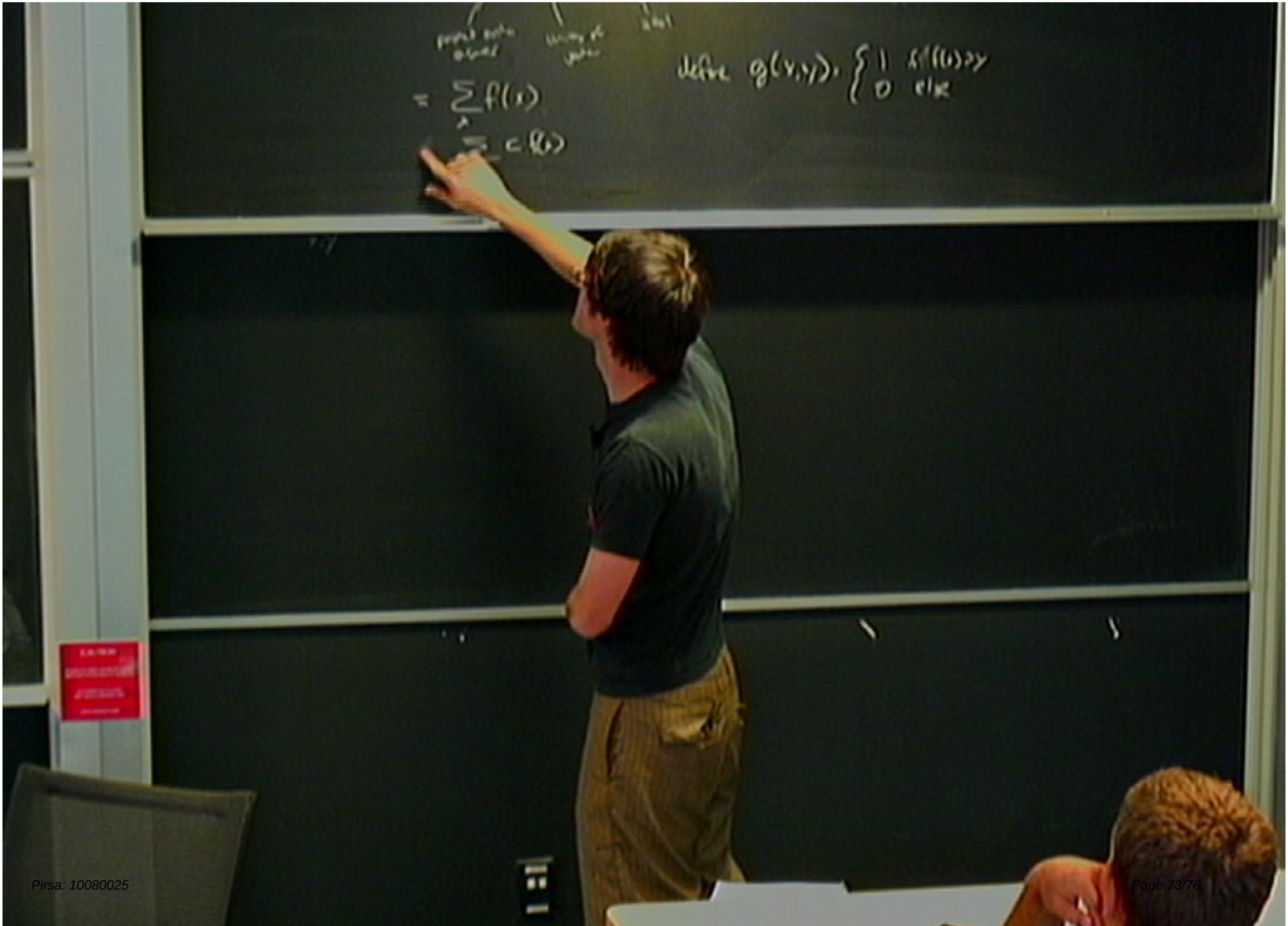

f, g
f = τ(g(σ(x)))

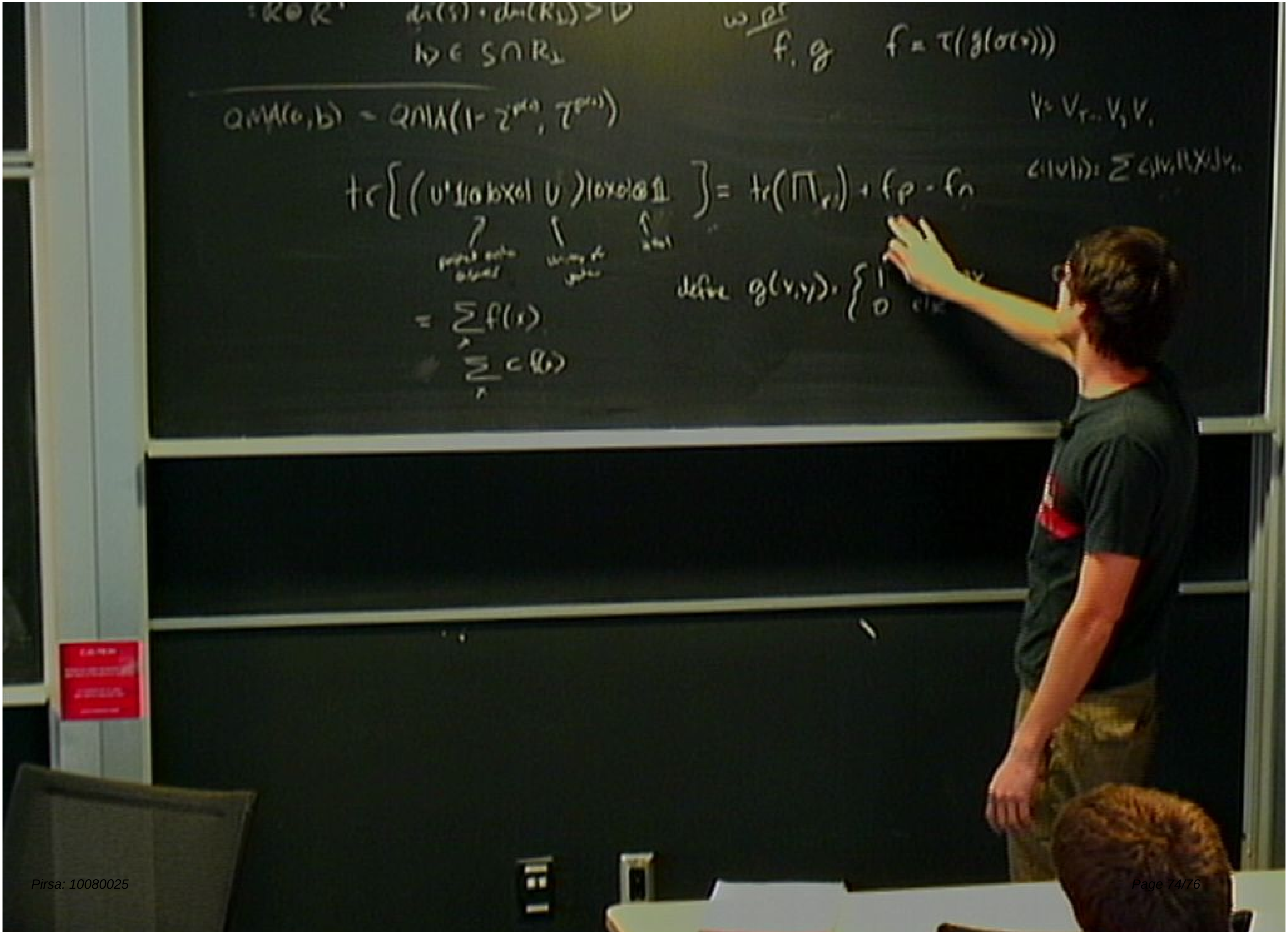


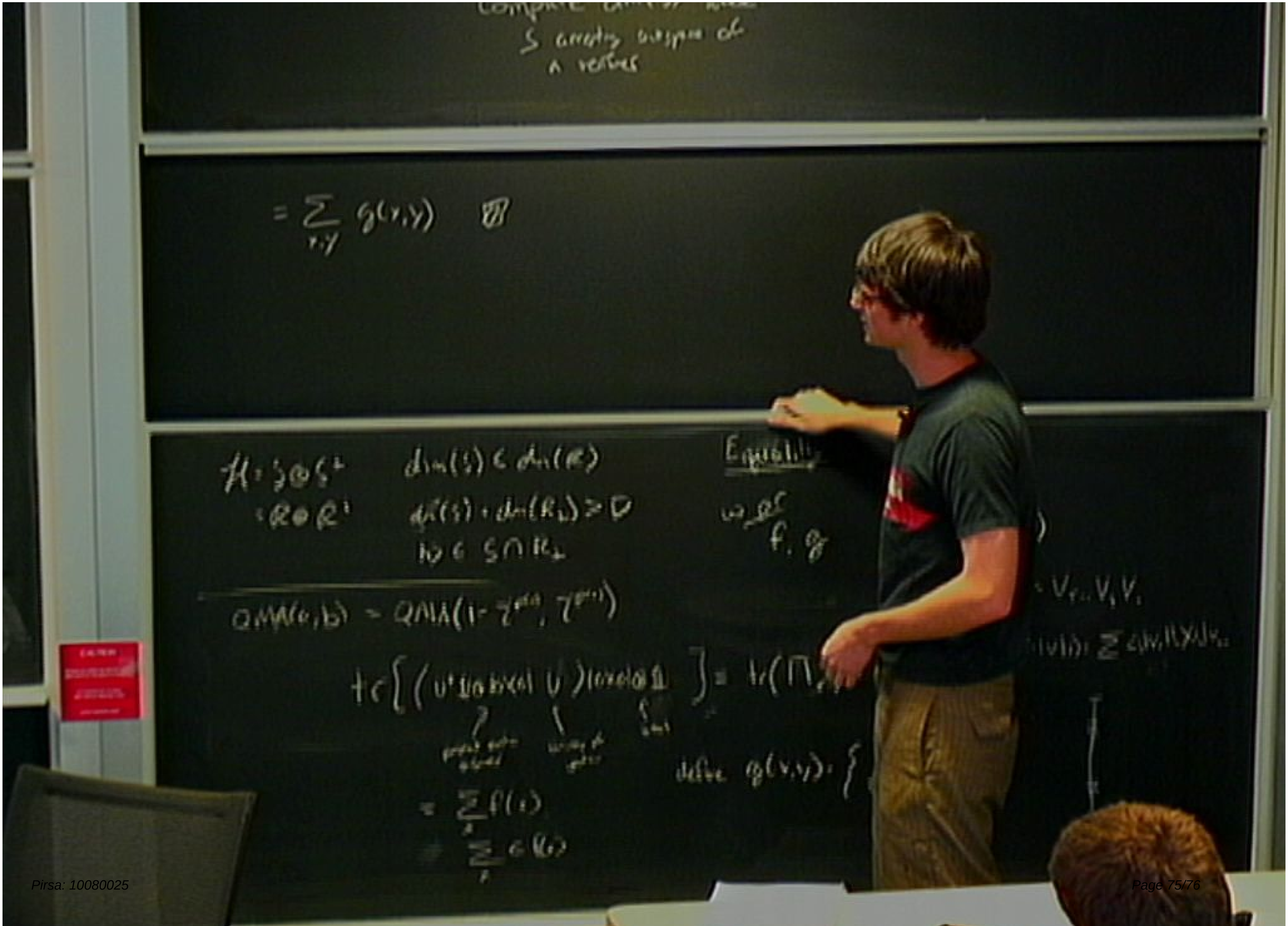


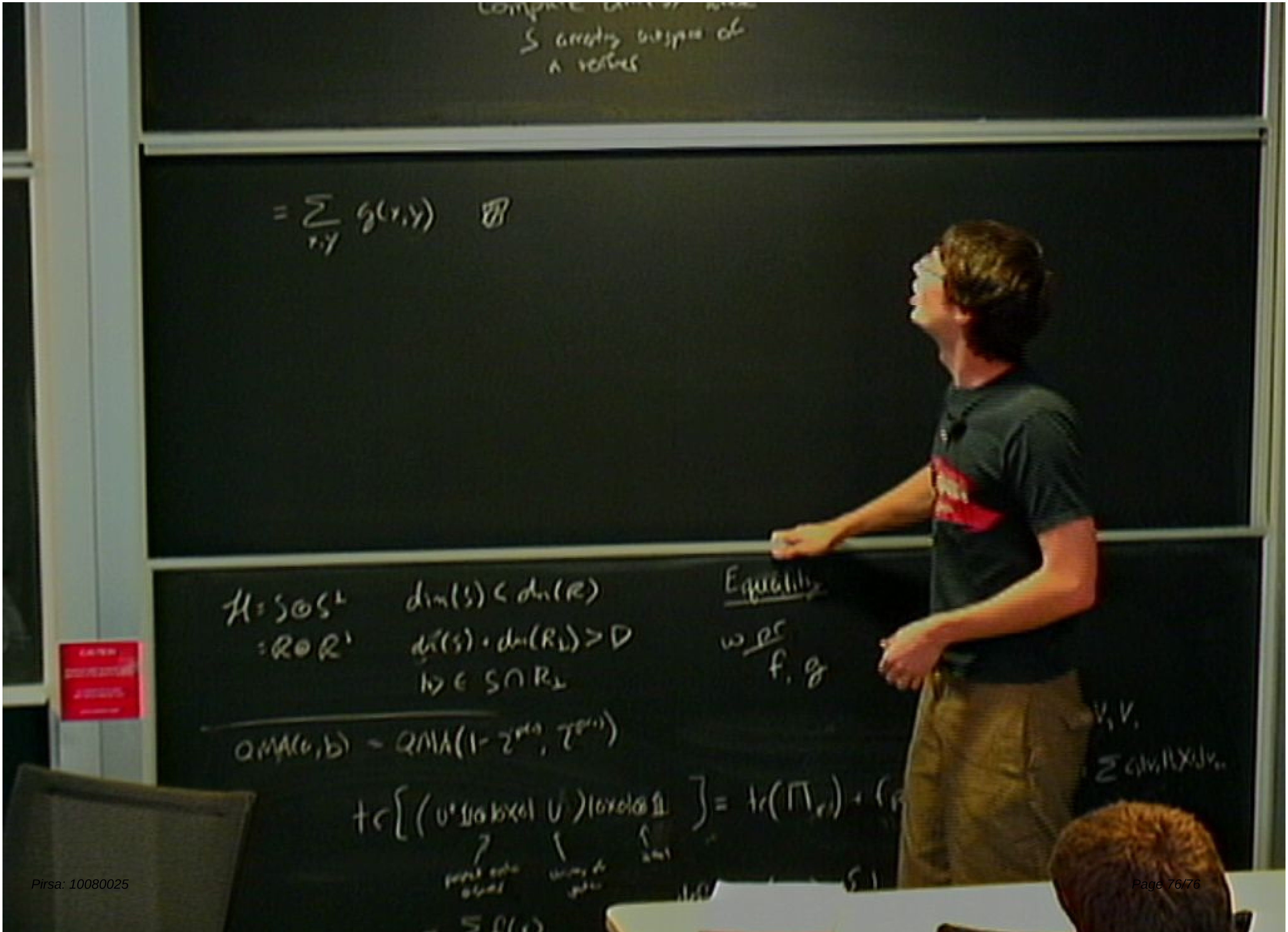





define g(x,y) = { 1 if f(x)≥y
0 else


f, g
define g(x,y) = { 1
0 else




dim(S) < dim(R)
Equality