Title: LECTURE: Tensor networks and quantum algorithms

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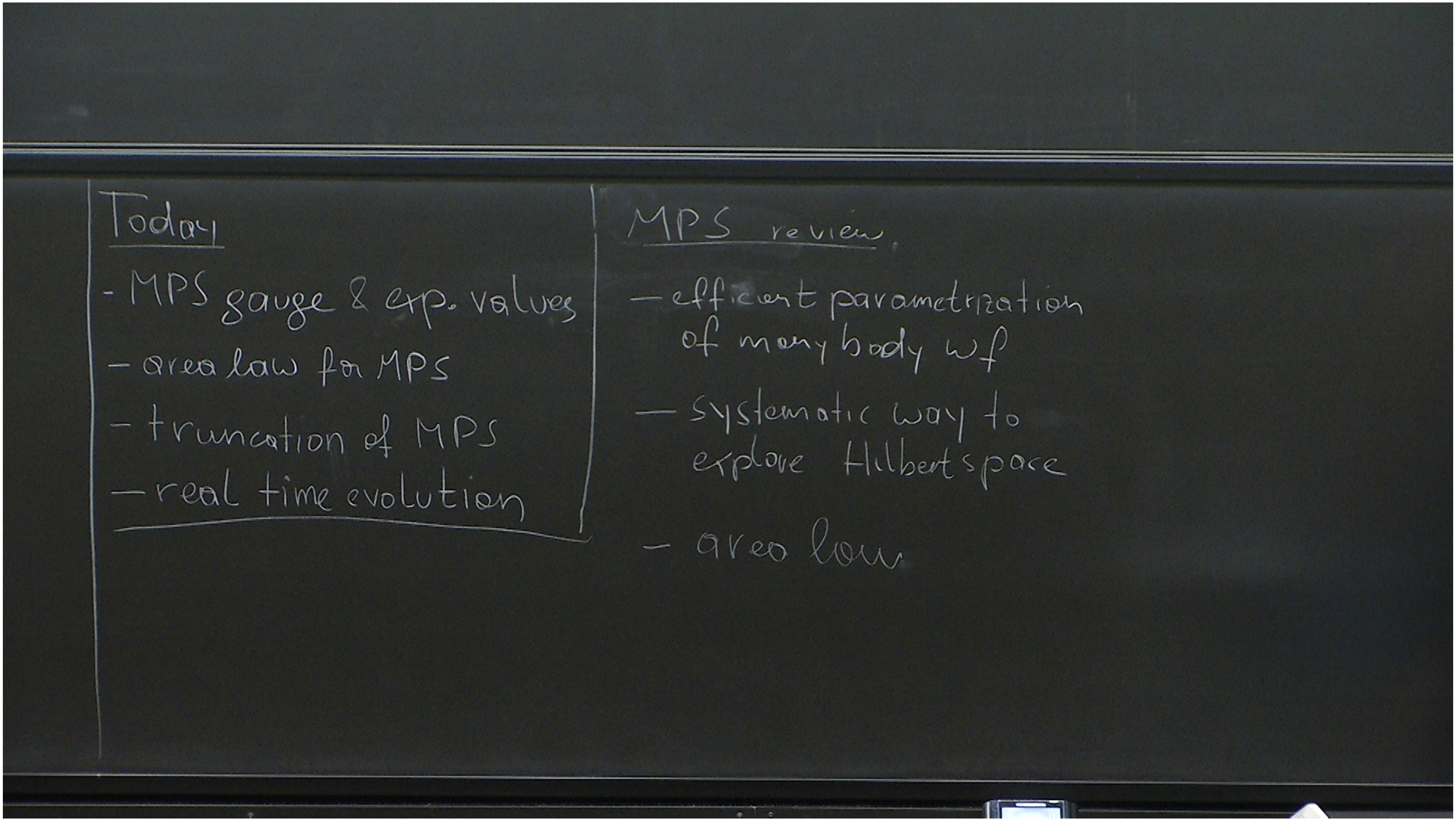
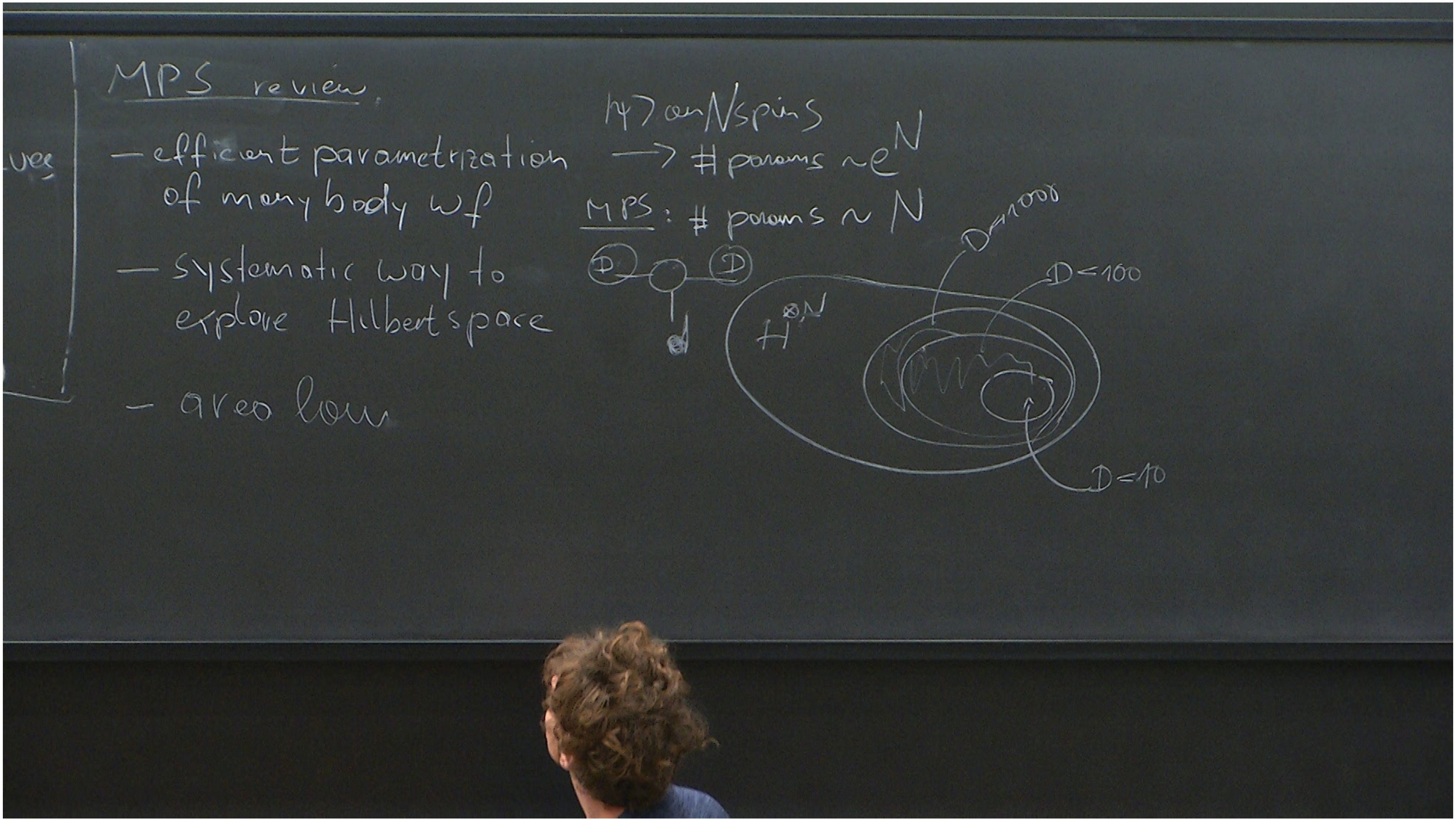
Collection: Quantum and AI Career Trajectories Mini-Course: Computational Methods and their Applications

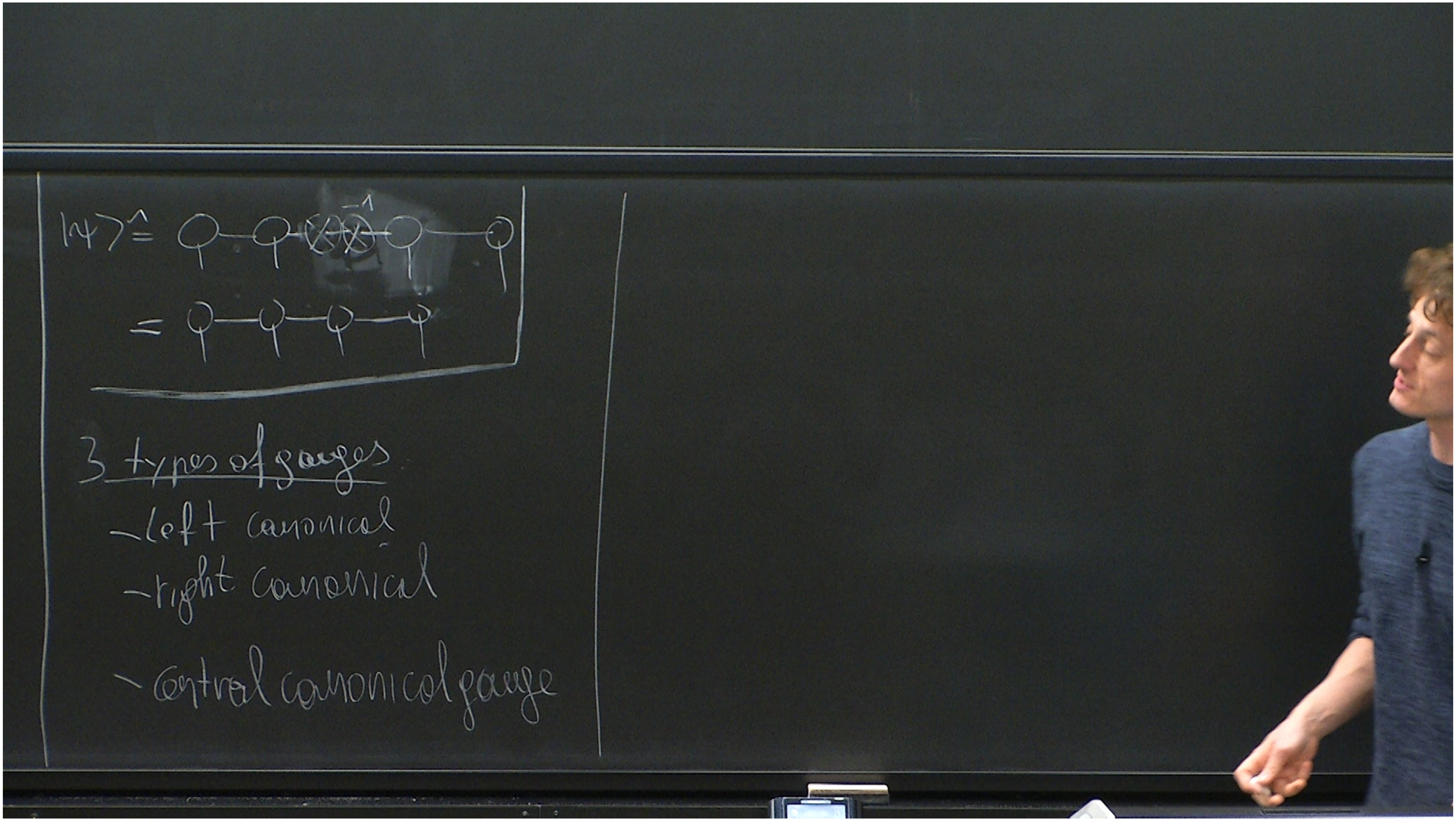
Date: May 10, 2023 - 9:30 AM

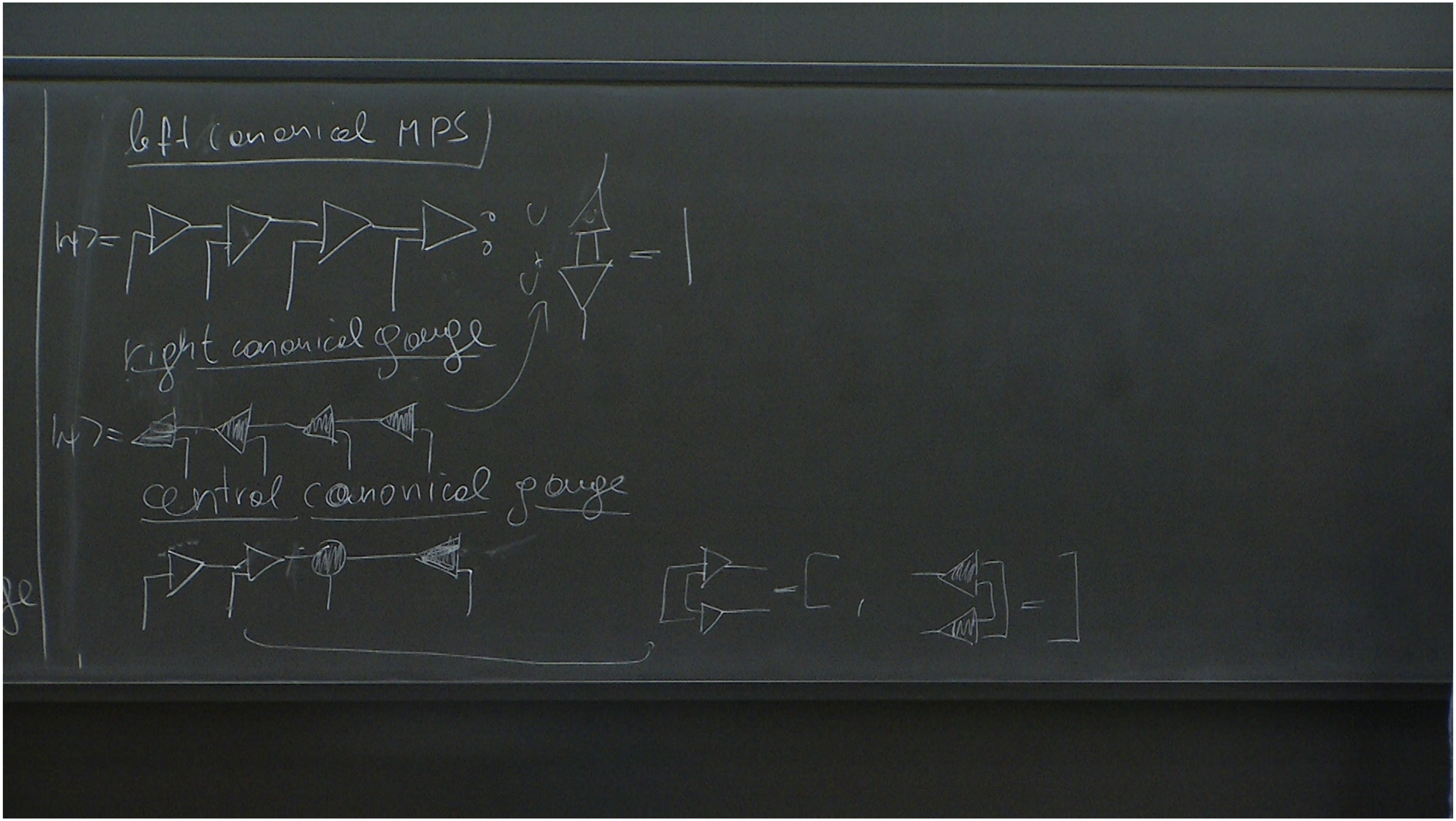
URL: https://pirsa.org/23050099

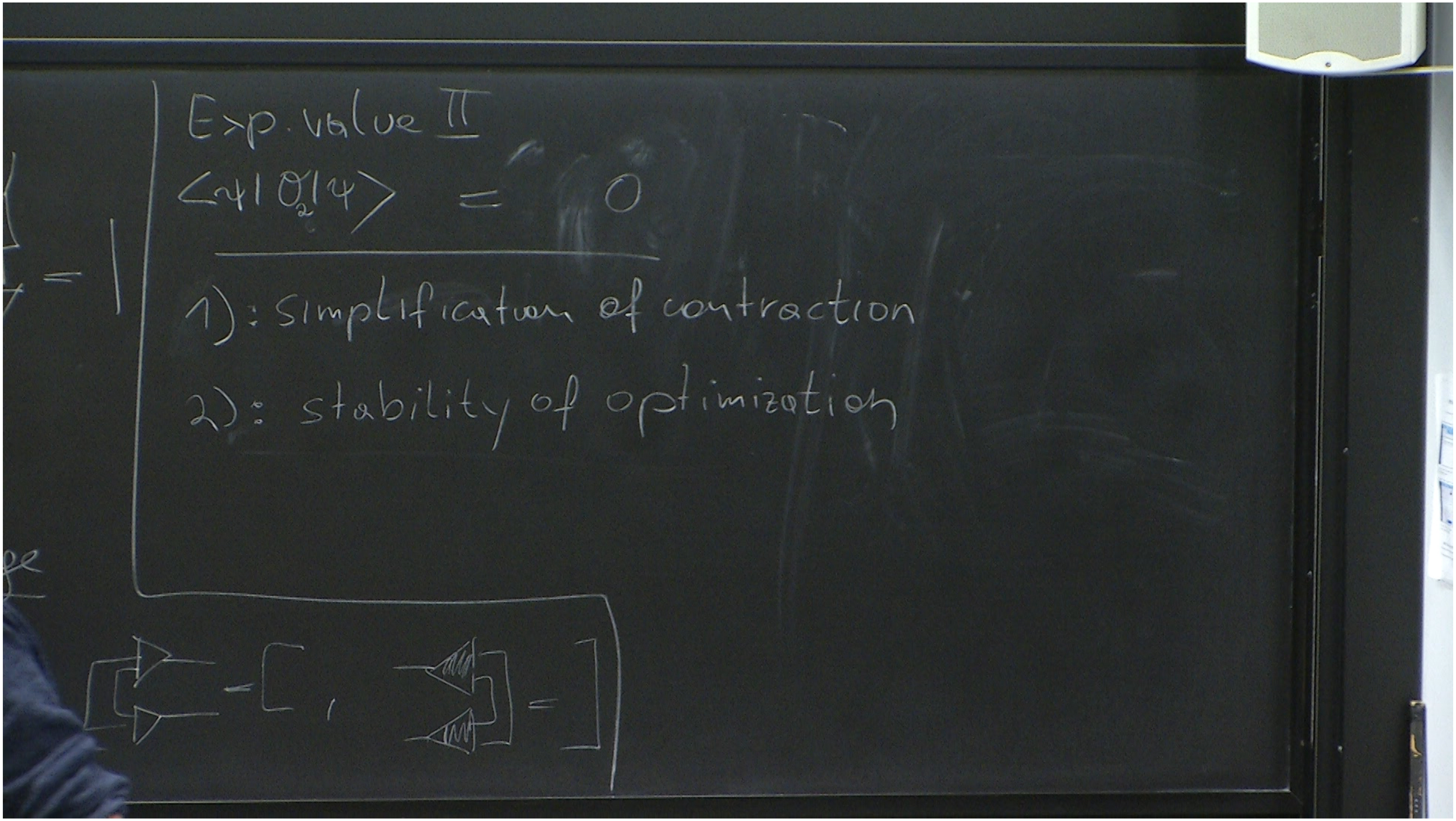
Abstract: TBC

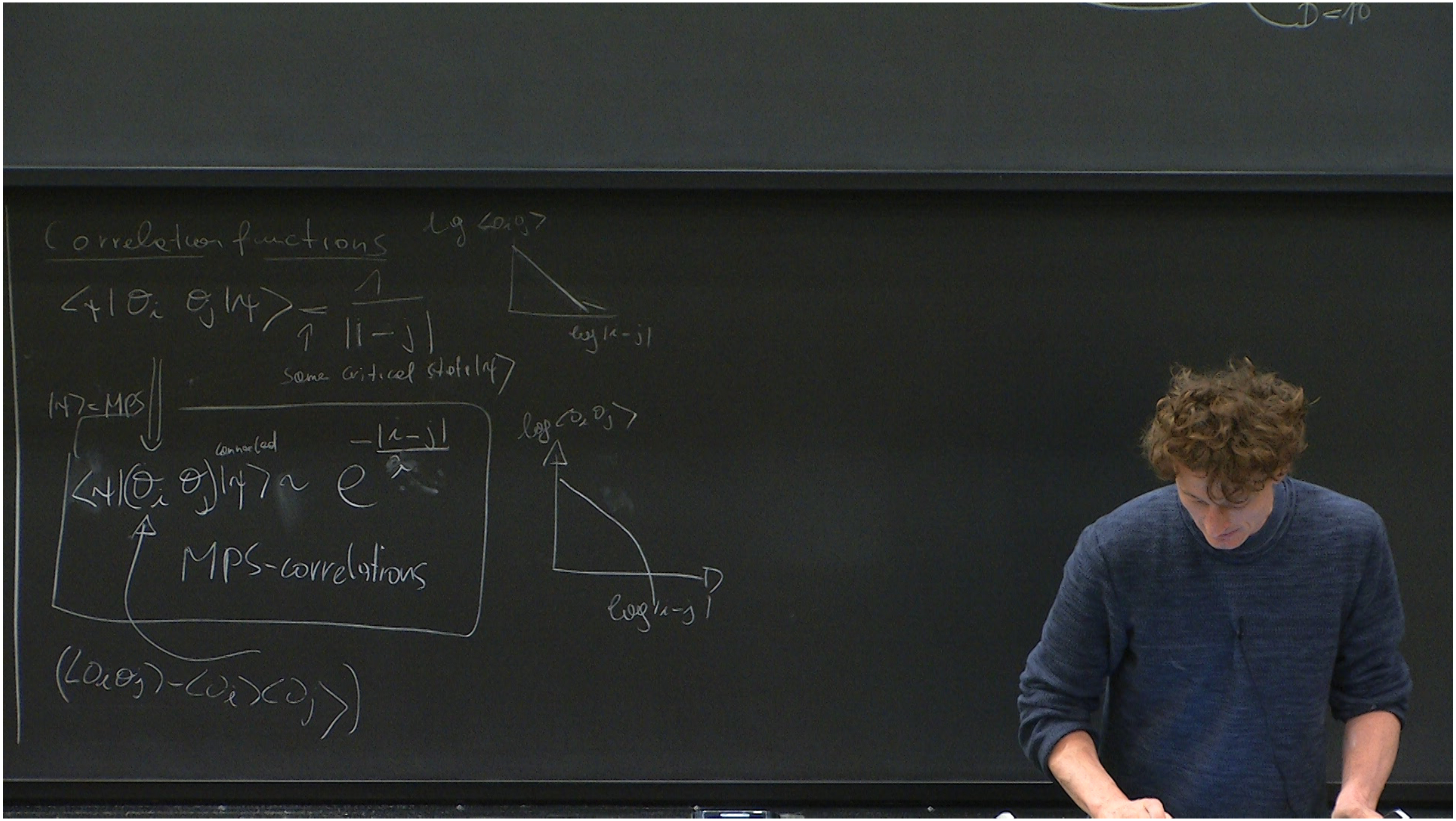

Today
- MPS gauge & exp. values
- area law for MPS
- truncation of MPS
- real time evolution
MPS review
- efficient parametrization of many body wf
- systematic way to explore Hilbert space
- area law

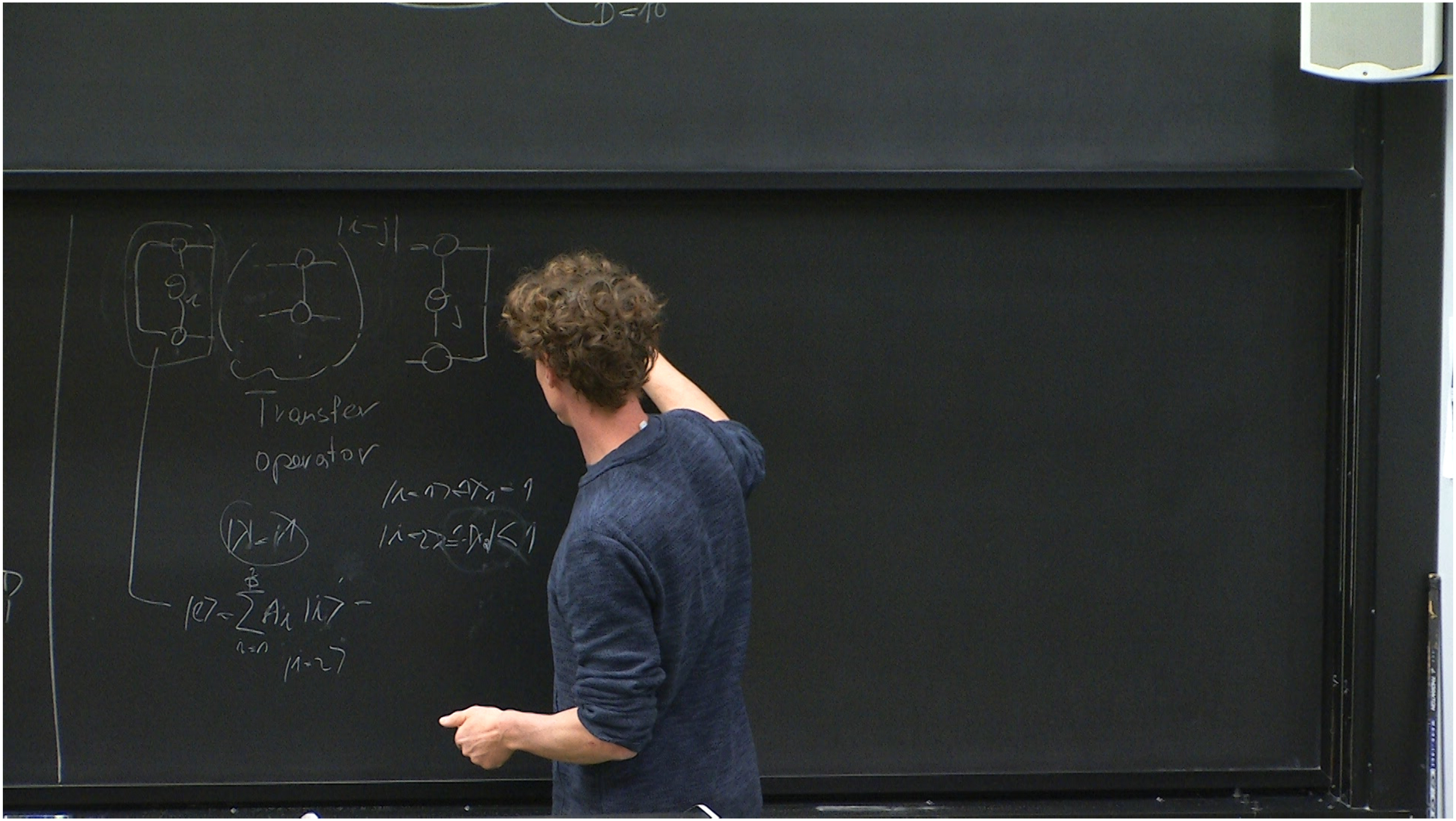

MPS review.
|ψ⟩ on N spins
— efficient parametrization of many body wf
→ # params ~ e^N
MPS: # params ~ N
— systematic way to explore Hilbert space
— area law
D
D
d
H^⊗N
D<1000
D<100
D<10

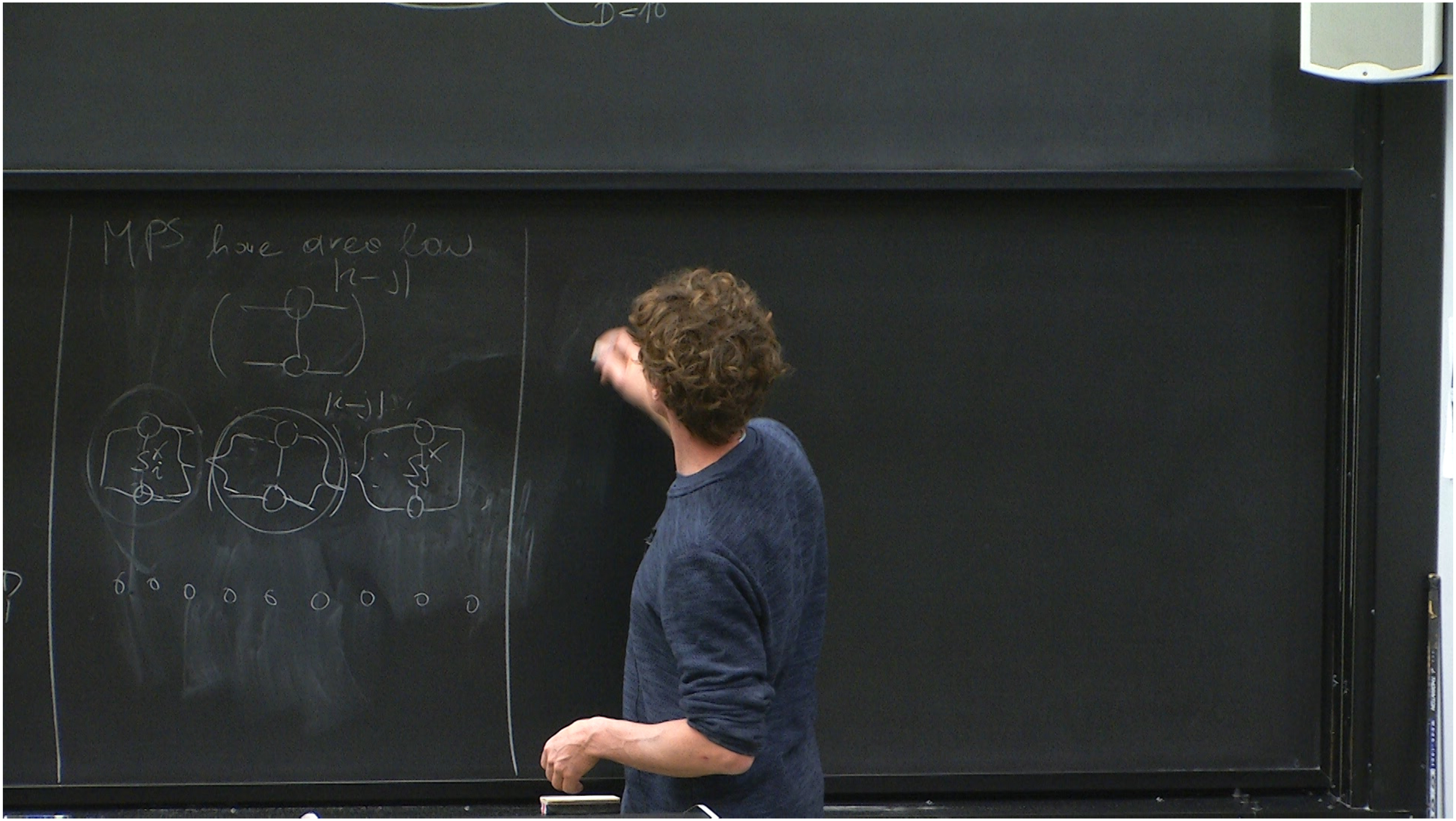

3 types of gauges
- left canonical
- right canonical
- central canonical gauge

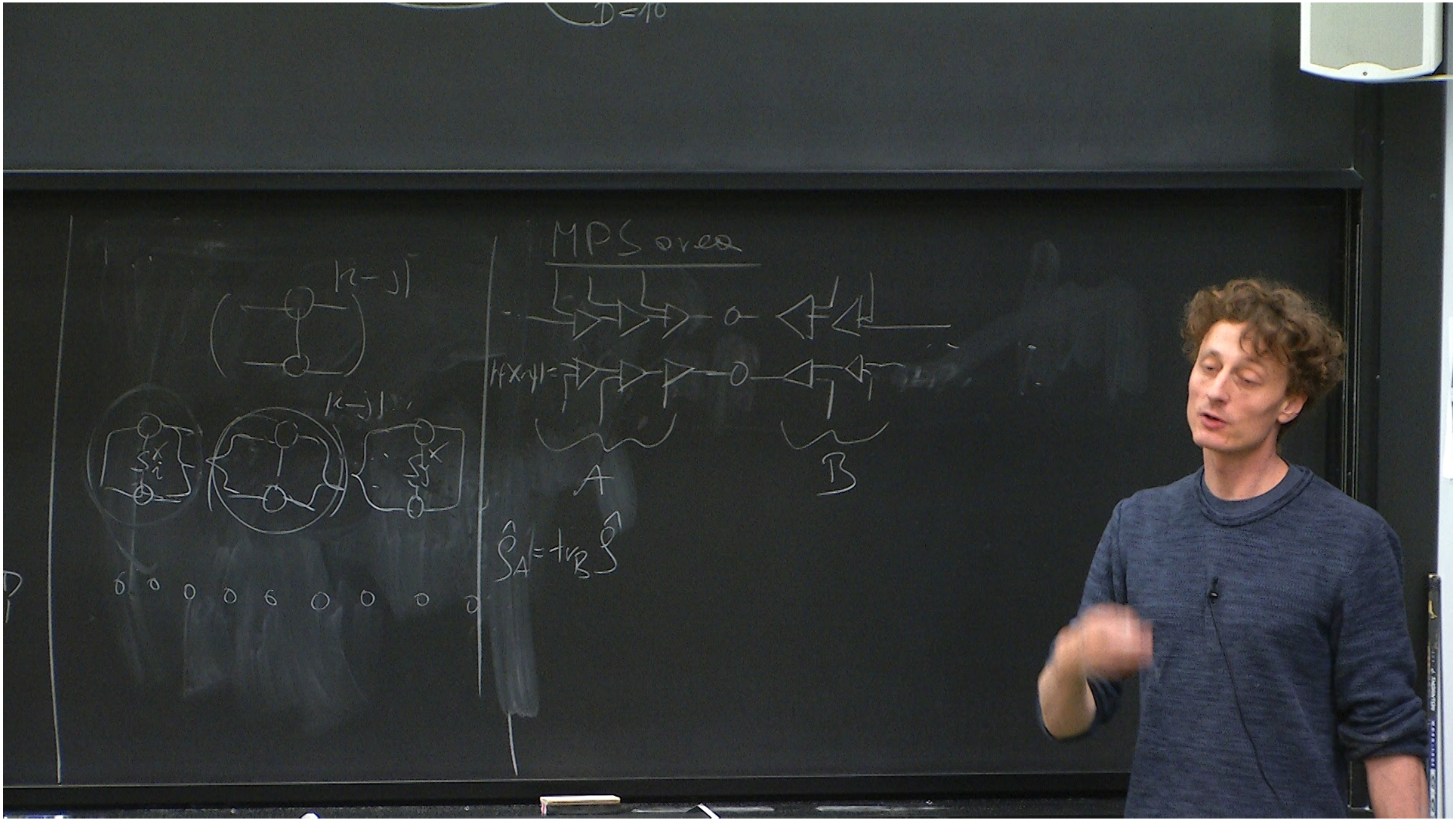

left canonical MPS
|ψ⟩=
right canonical gauge
|ψ⟩=
central canonical gauge

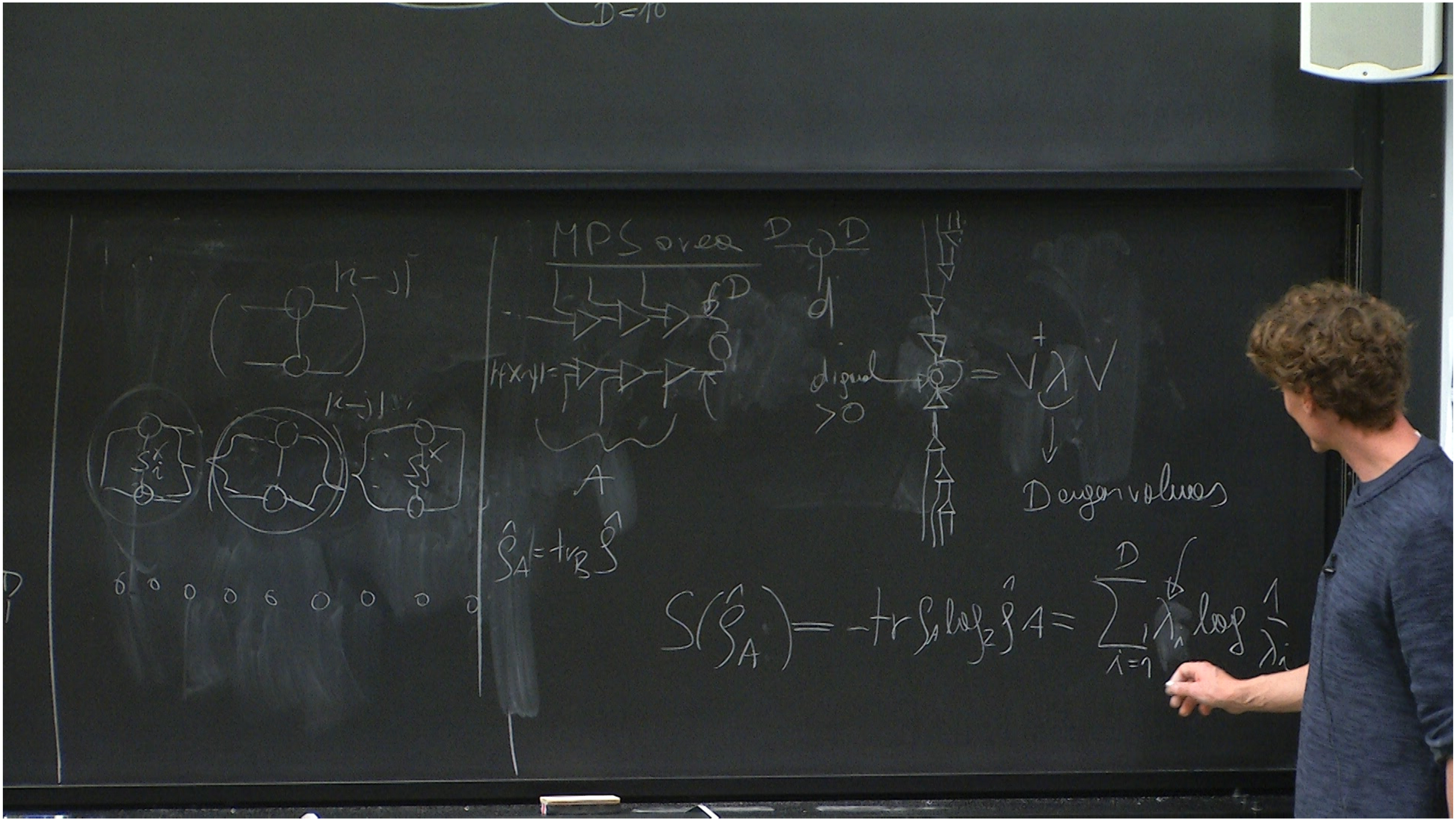

Exp. value II
⟨ψ| O₂ |ψ⟩ = 0
1): simplification of contraction
2): stability of optimization

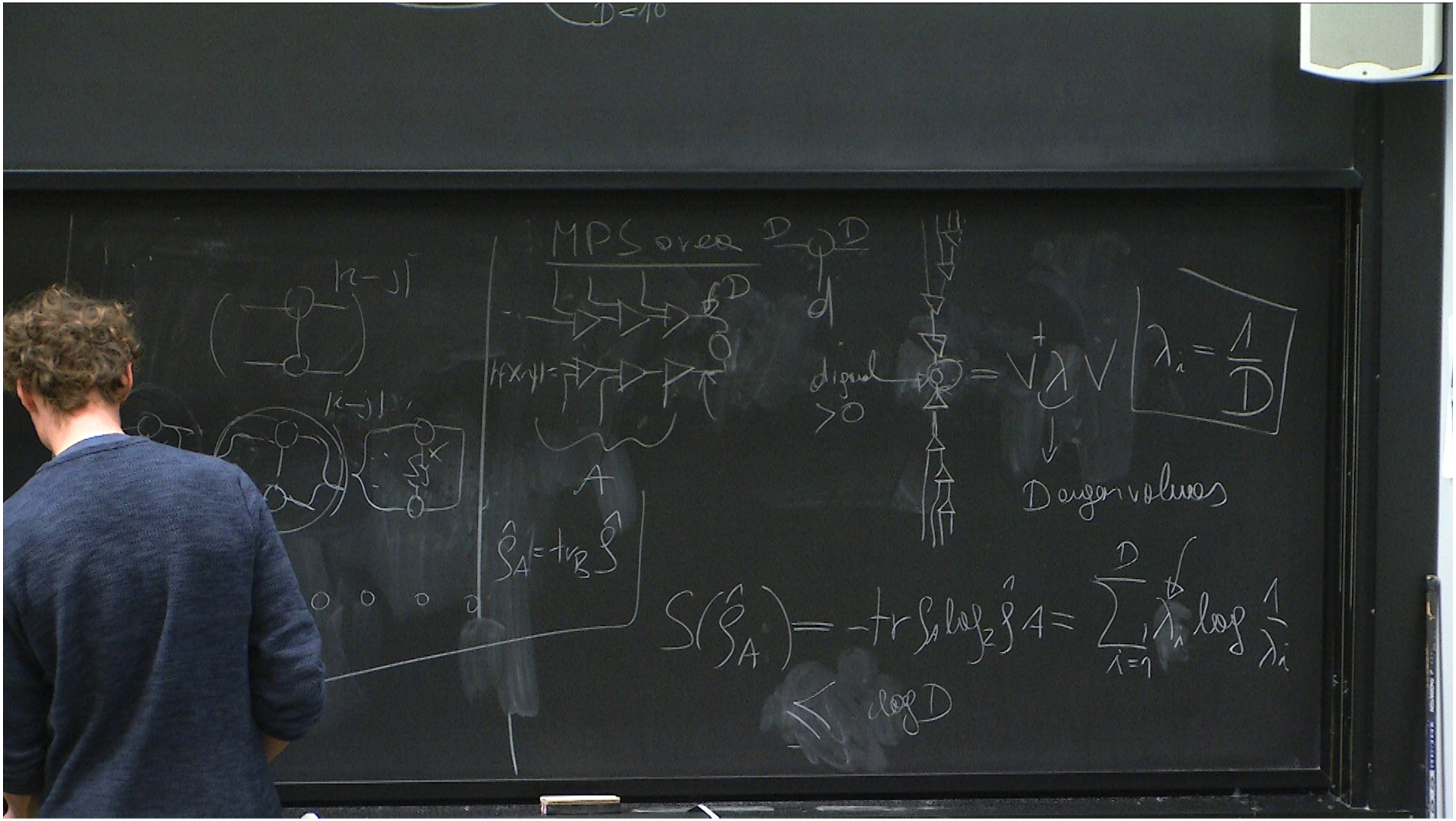

D<10
Correlation functions
log ⟨O_i O_j⟩
⟨ψ| O_i O_j |ψ⟩ ~ 1 / |i − j|
log |i − j|
some critical state |ψ⟩
|ψ⟩ = MPS
connected
⟨ψ| O_i O_j |ψ⟩ ~ e^{−|i−j|/λ}
MPS-correlations
log ⟨O_i O_j⟩
log |i − j|
(⟨O_i O_j⟩ − ⟨O_i⟩⟨O_j⟩)

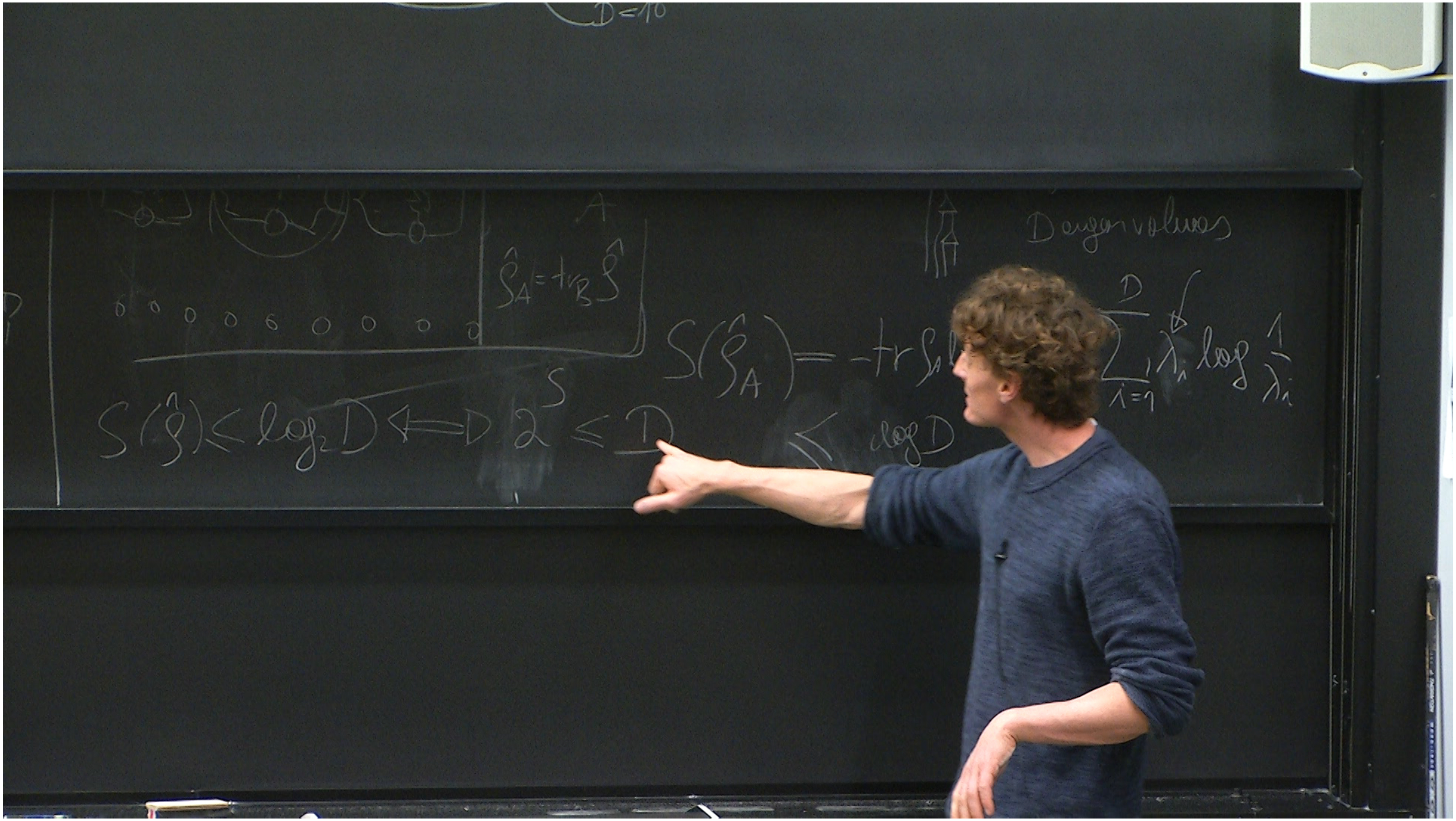

Transfer
operator

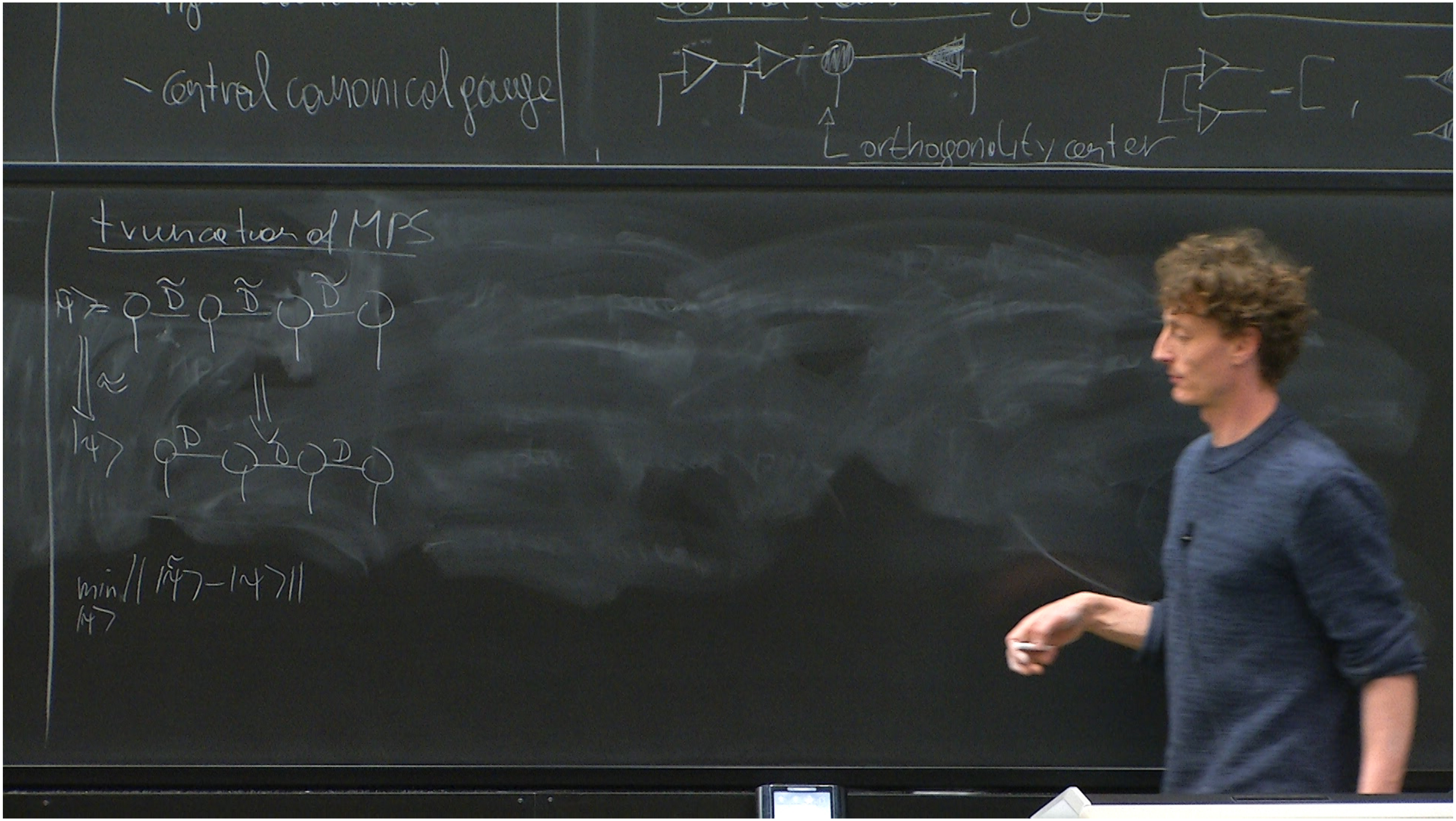

MPS have area law

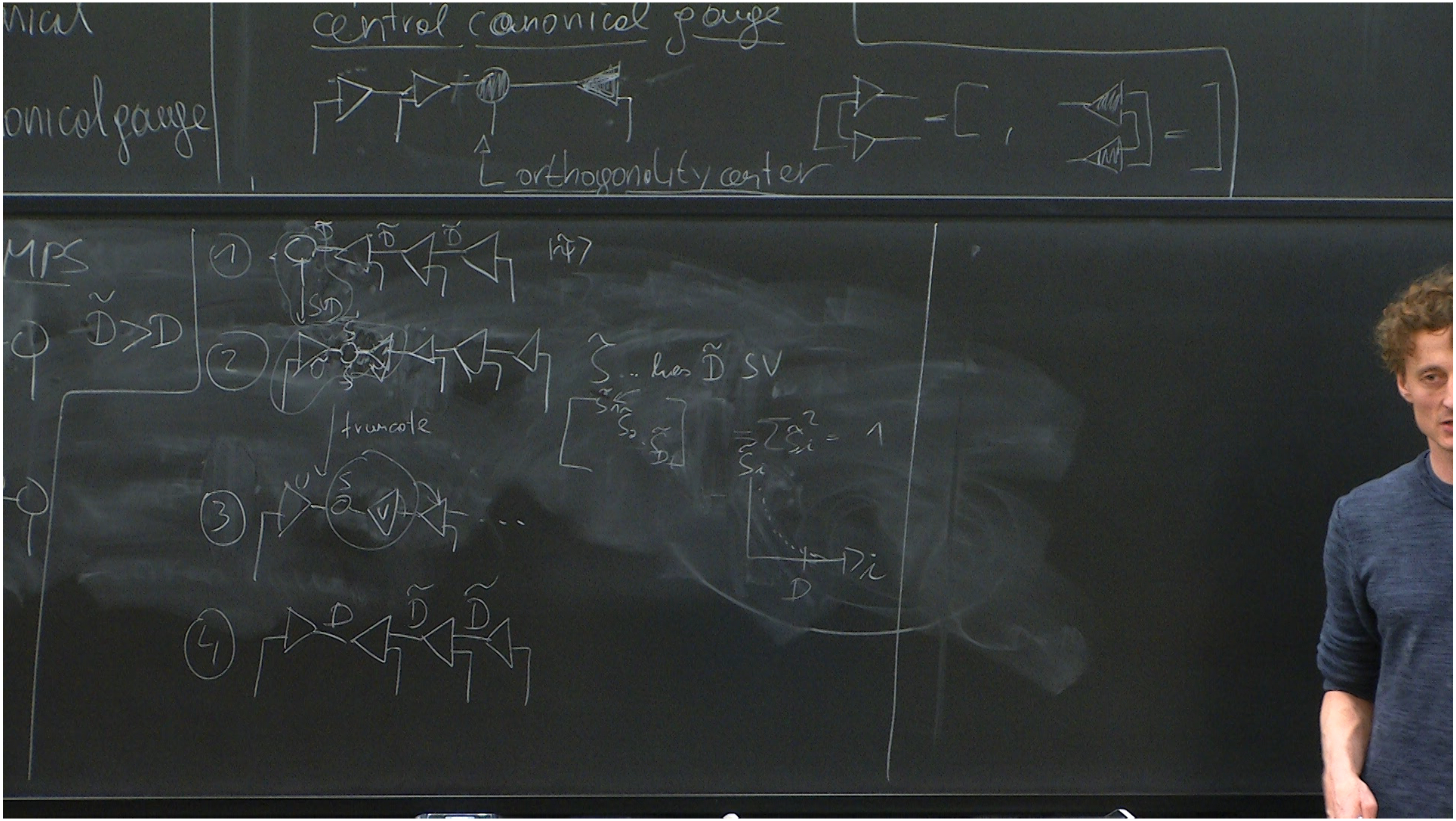

MPS area
A
B

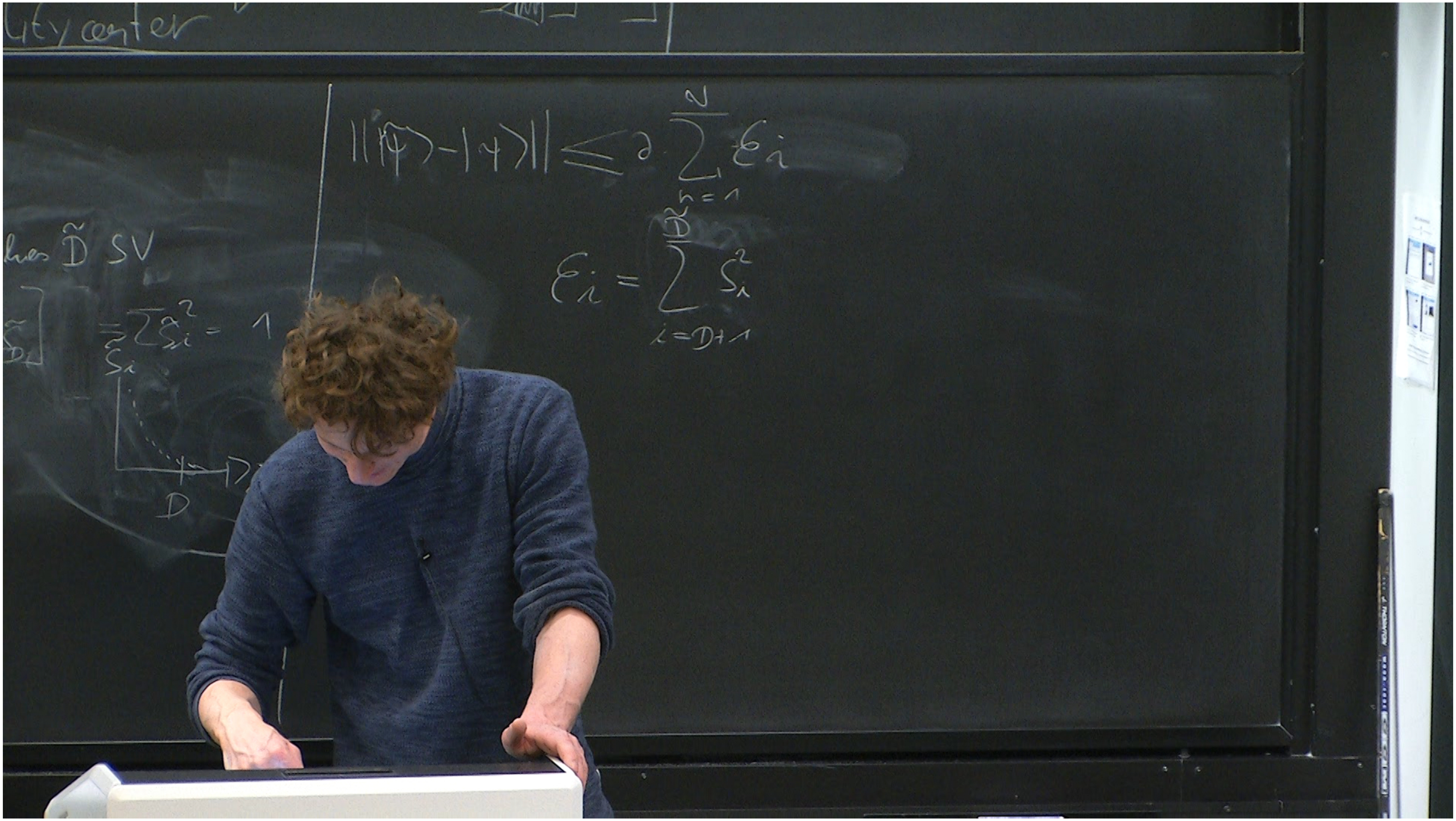

MPS area
D eigenvalues


MPS area
D eigenvalues
λi = 1/D
≤ log D

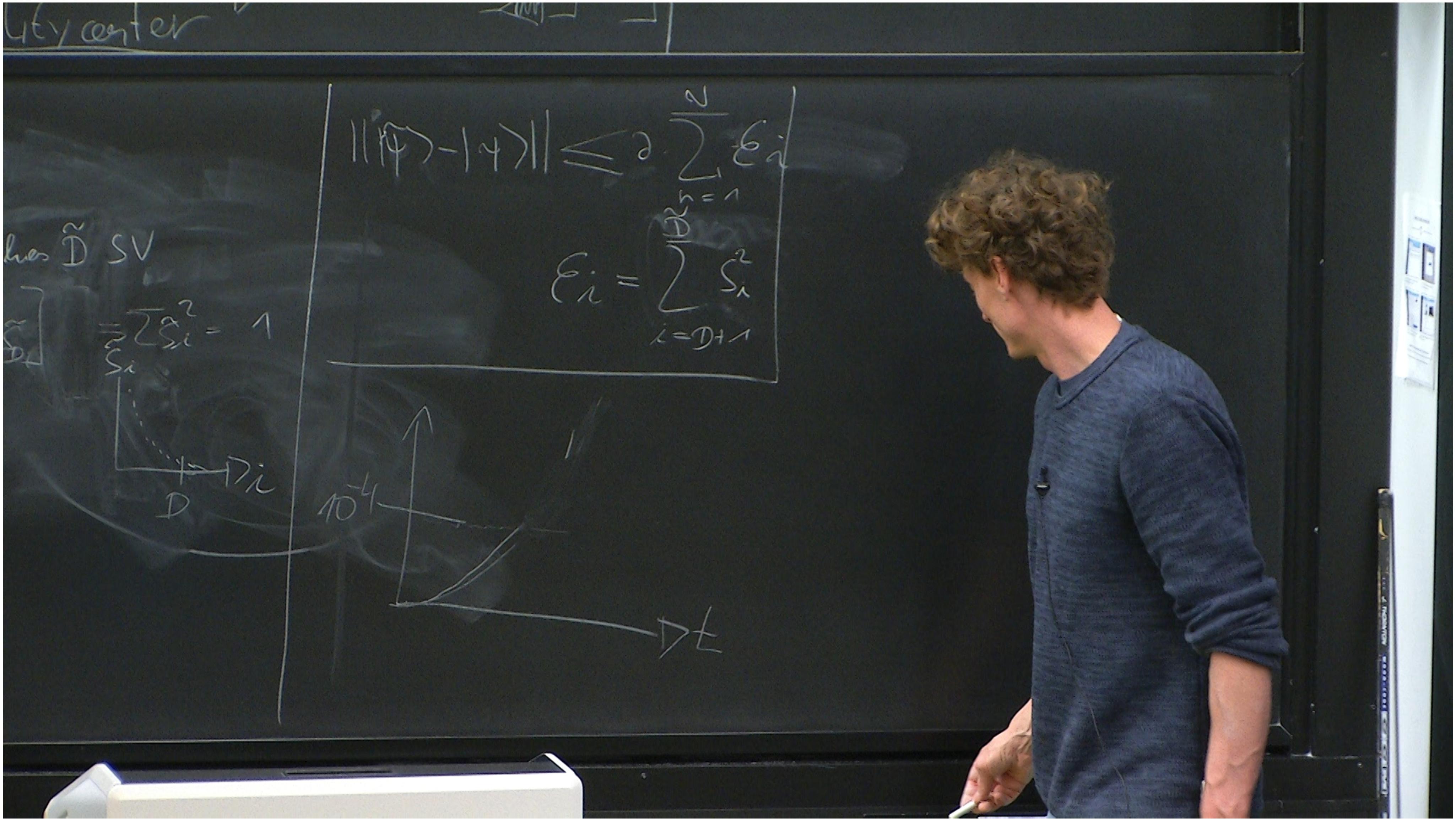

D eigenvalues
$\hat{\rho}_A = tr_B \hat{\rho}$
$S(\hat{\rho}_A) = -tr\,\rho_A \log\rho_A = \sum_{i=1}^{D} \lambda_i \log \frac{1}{\lambda_i}$
$S(\hat{\rho}) \leq \log_2 D \Longleftrightarrow 2^S \leq D$
$\leq \log D$


- central canonical gauge
orthogonality center
truncation of MPS
min || |ψ̃⟩ − |ψ⟩ ||


central canonical gauge
orthogonality center
MPS
truncate
has D̃ SV



$|| |\tilde{\psi}\rangle - |\psi\rangle || \leq 2 \sum_{n=1}^{N} \varepsilon_n$
$\varepsilon_n = \sum_{i=D+1}^{\tilde{D}} S_i^2$



SV
10^-4
Dt