Title: Quantum Foundations Lecture - 230206

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Collection: Quantum Foundations (2022/2023)

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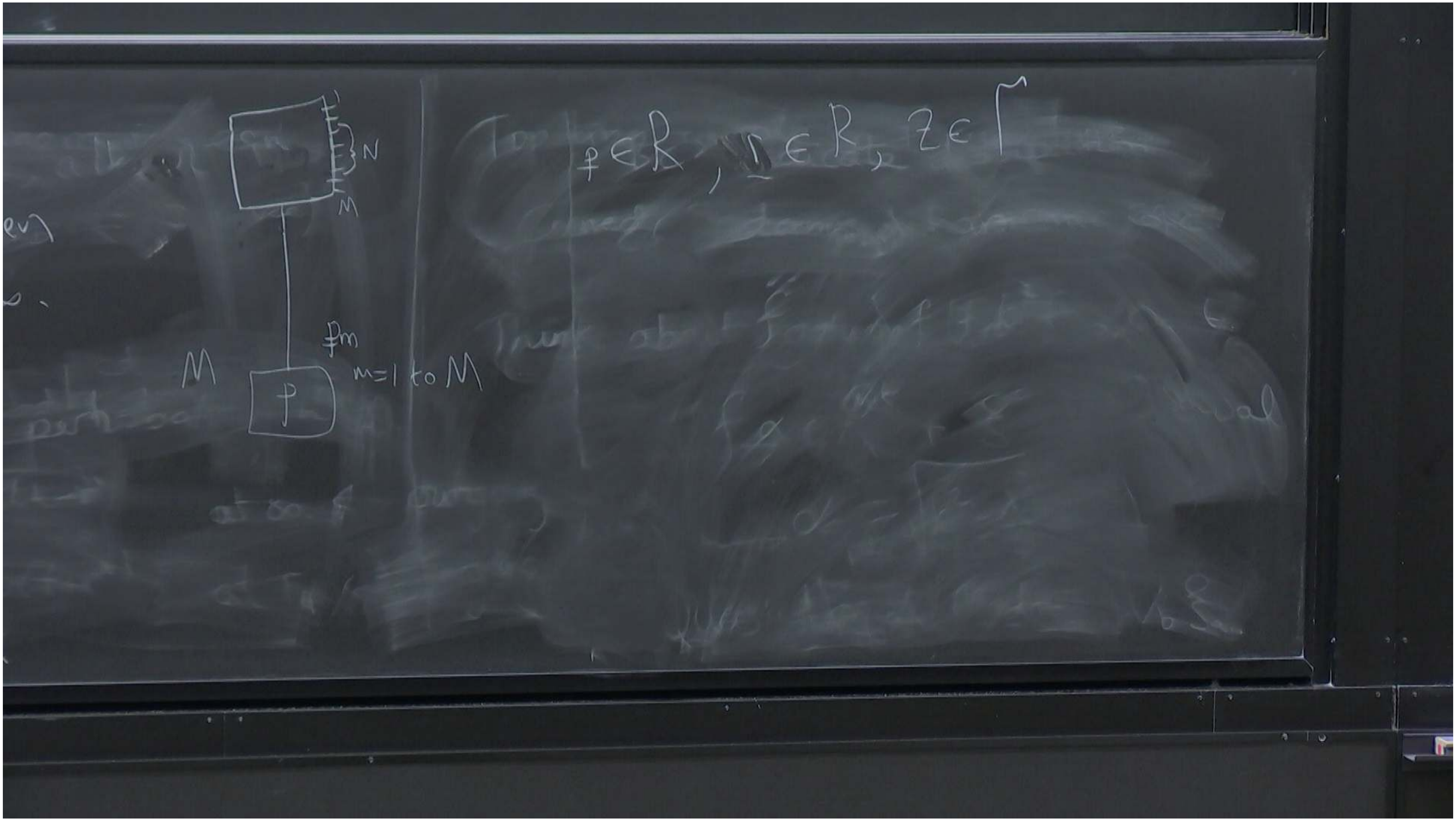

N
M
fm
M
f
m=1 to M
f ∈ R , ∈ R, z ∈ Γ

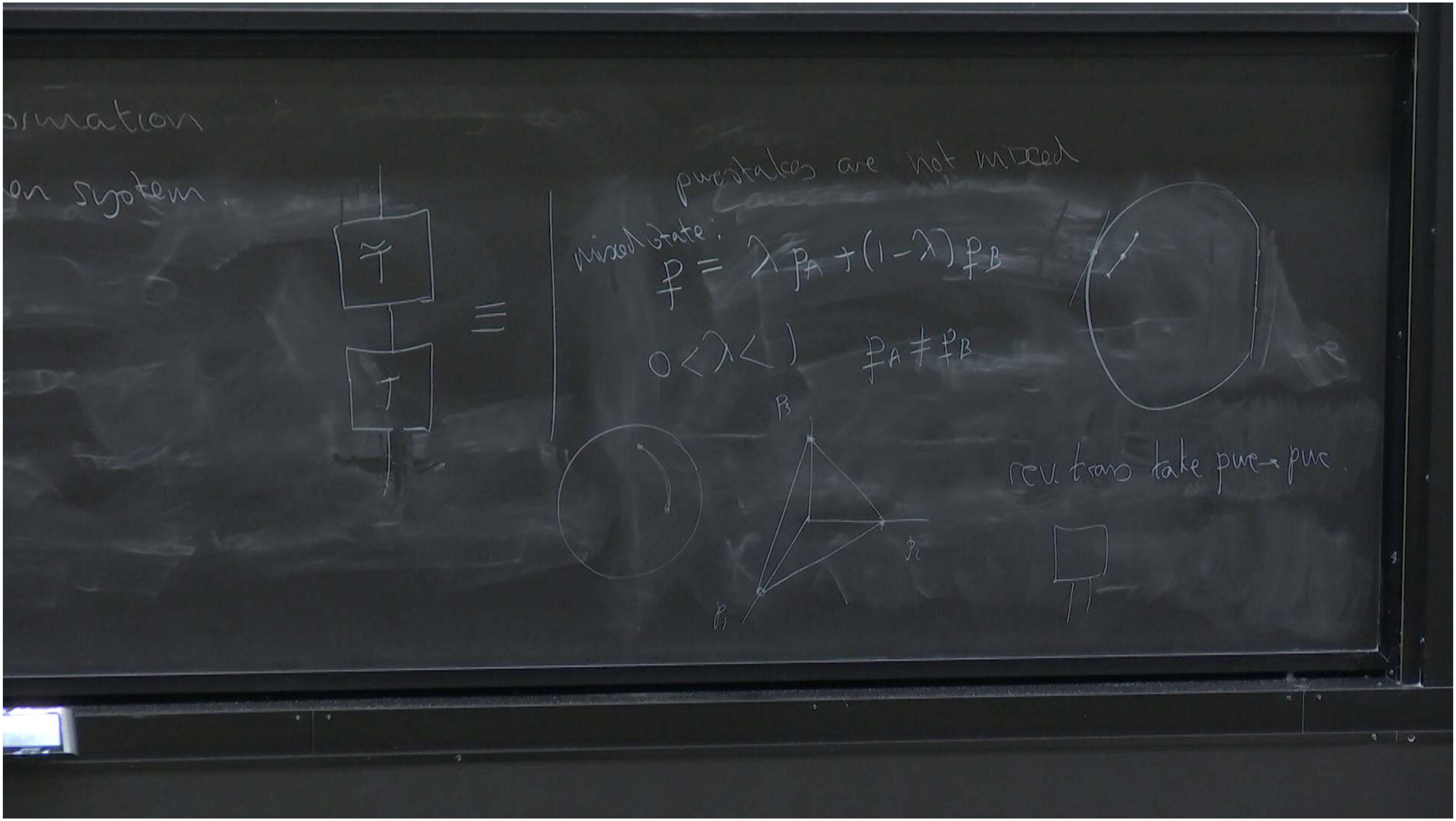
Postulates for QT.

1. Information. Systems having, or constrained to have, a
information carrying capacity have the same prop

2. Information locality $N_{ab} = N_a N_b$

3. Tomographic locality $K_{ab} = K_a K_b$

(4) Continuity There exists a continuous reversible transformation between any pair of pure states for any given system


ormation
en system
purestates are not mixed
mixed state:
ρ = λ ρA + (1−λ) ρB
0 < λ < 1
ρA ≠ ρB
rev. trans take pure → pure

④ Continuity — There exists a continuous reversible transformation between any pair of pure states for any given system.

⑤ Simplicity — Systems are described by the smallest number of probabilities consistent with the other postulates.
(for each N, K should be as small as possible)

$K = N^r$ $\quad K = N\!\!\times \quad K = N^2$

The shape of Quantum State space

$$K = N^2$$

Normalised states $K-1 = N^2-1$

Boundary of the normalised statespace $K-2 = N^2-2$

Dim of pure states =

The shape of Quantum State space

$K = N^2$

Normalised states $K-1 = N^2-1$

Boundary of the normalised state space $K-2 = N^2-2$

Dim of pure states $= 2N-2$

$$|\psi\rangle = \sum_{n=1}^{N} a_n |n\rangle$$

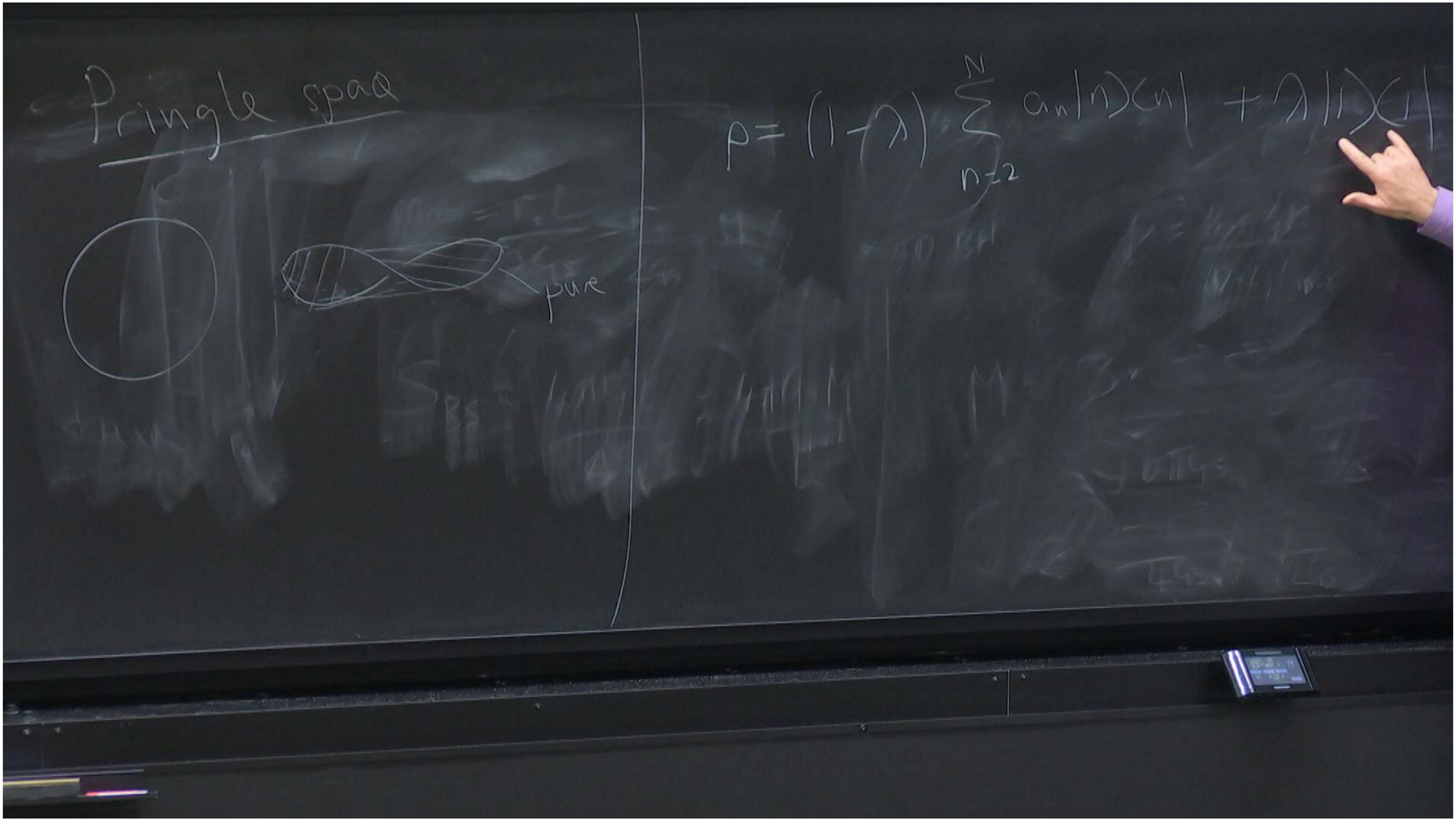
$N=2$ $K=4$

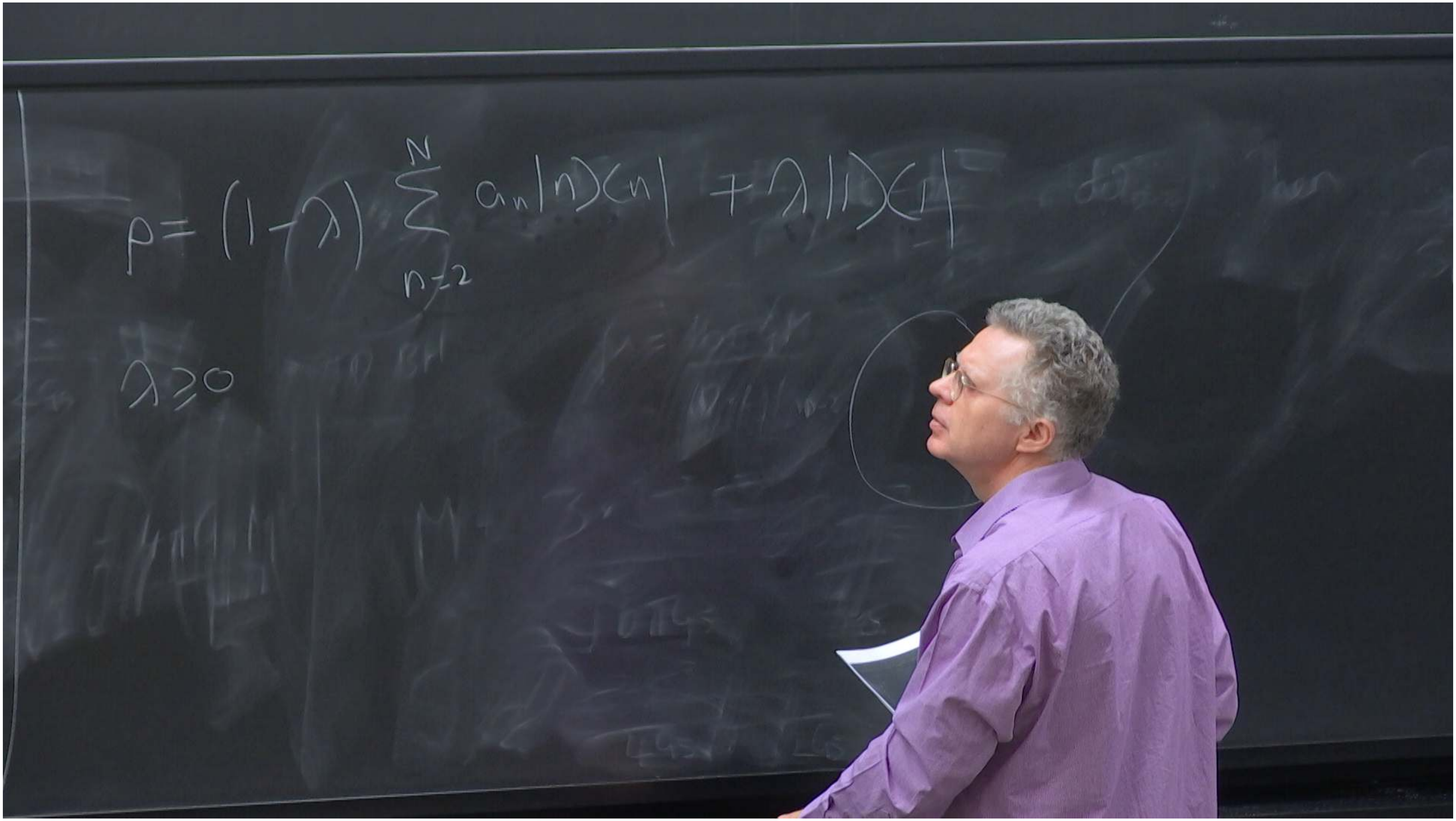
$K-1=3$

$K-2=2$

pure dim $=2$

$N=3$


Pringle space
pure
$\rho = (1-\lambda) \sum_{n=2}^{N} a_n |n\rangle\langle n| + \lambda |1\rangle\langle 1|$


$\rho = (1-\lambda) \sum_{n=2}^{N} a_n |n\rangle\langle n| + \lambda |1\rangle\langle 1|$
$\lambda \geq 0$

$$\rho = \rho^2 \quad \text{cond for purity}$$

$$\Updownarrow$$

$$\begin{pmatrix} p_1 \\ p_2 \\ \vdots \\ p_K \end{pmatrix}$$

$$p_K = \text{quadratic fn of } \vec{p}$$

$$= q_K(\vec{p})$$

N^2 quadratic eqns.

Jones Linden 2004 | Fuchs 0906.2187
0910.2750

ρ is Hermitian

$$\mathrm{tr}(\rho^2) = \mathrm{tr}(\rho^3) = 1$$

$\Rightarrow \rho$ is pure

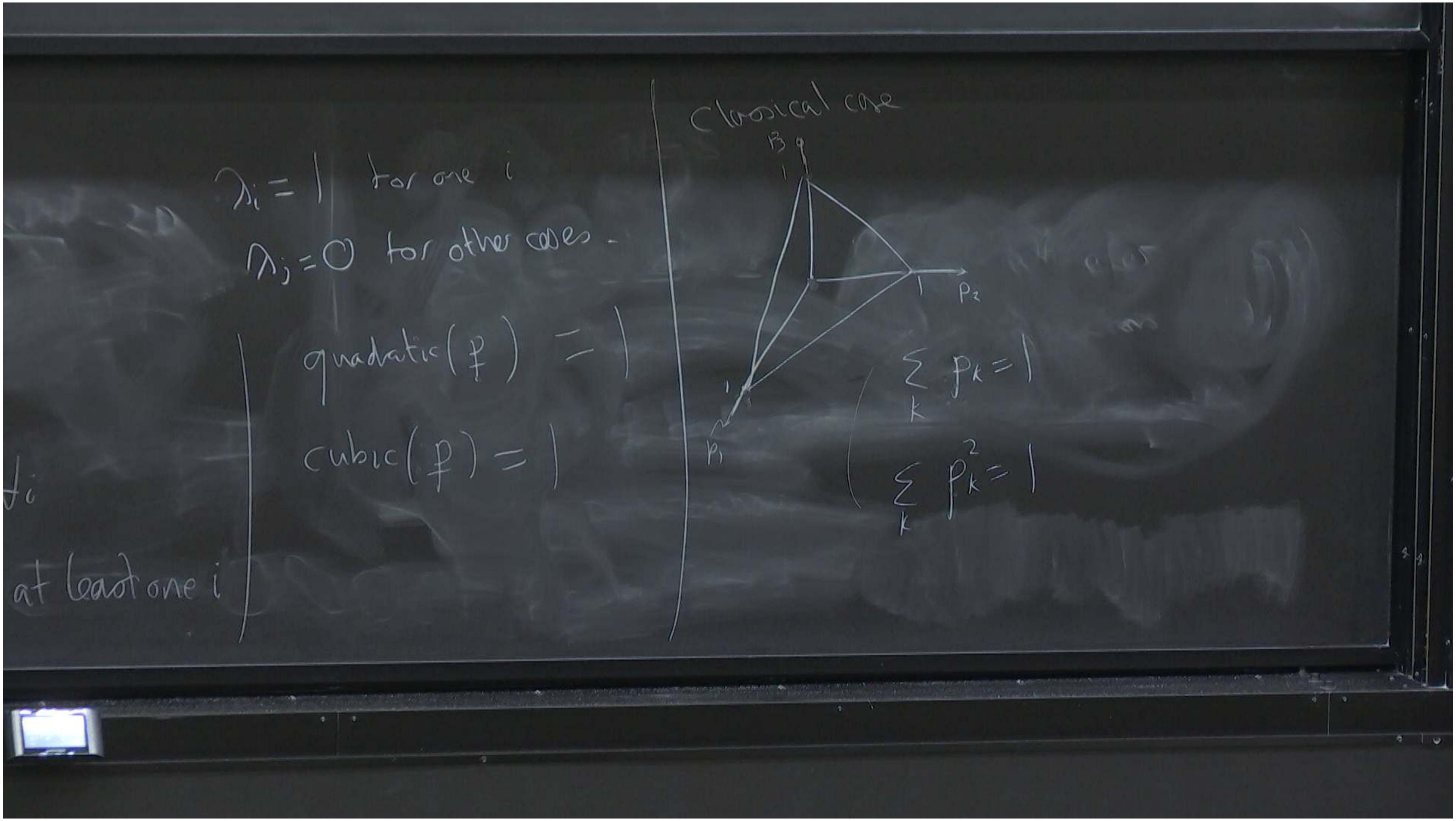
ρ has eigenvalues λ_i

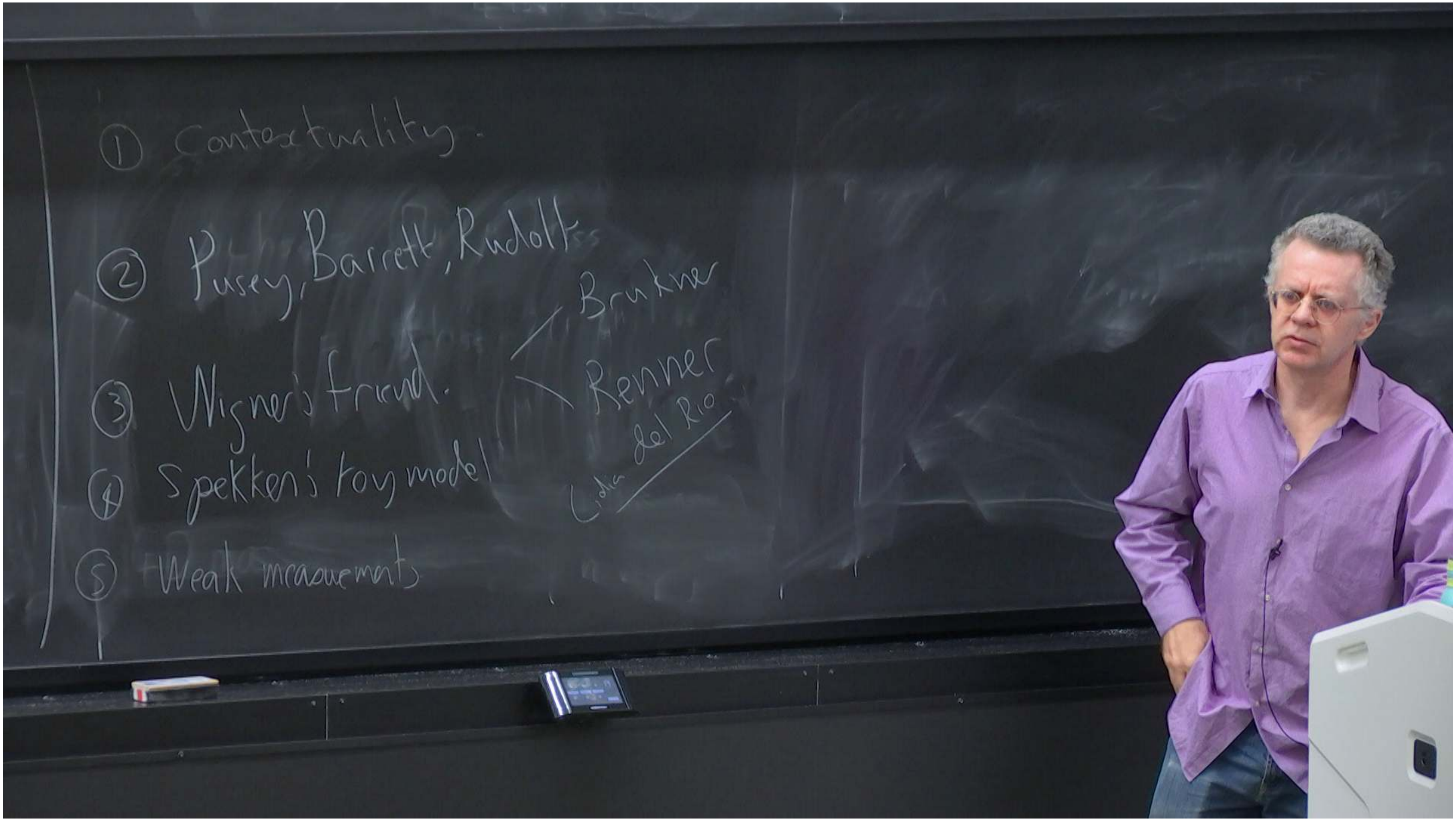
(1) $\sum_i \lambda_i^2 = 1$

(2) $\sum_i \lambda_i^3 = 1$

$|\lambda_i| \leq 1 \Rightarrow 1 - \lambda_i \geq 0 \ \forall i$

(1)−(2) $\sum_i \underbrace{\lambda_i^2}_{\neq 0} \underbrace{(1-\lambda_i)} = 0$ $\lambda_i = 1$ for at least one


$\lambda_i = 1$ for one i
$\lambda_j = 0$ for other cases.
quadratic(p) = 1
cubic(p) = 1
at least one i
Classical case
p_3
p_2
p_1
1
$\sum_k p_k = 1$
$\sum_k p_k^2 = 1$


① Contextuality.
② Pusey, Barrett, Rudolph
③ Wigner's friend.
Brukner
Renner
Lidia del Rio
④ Spekken's toy model
⑤ Weak measurements