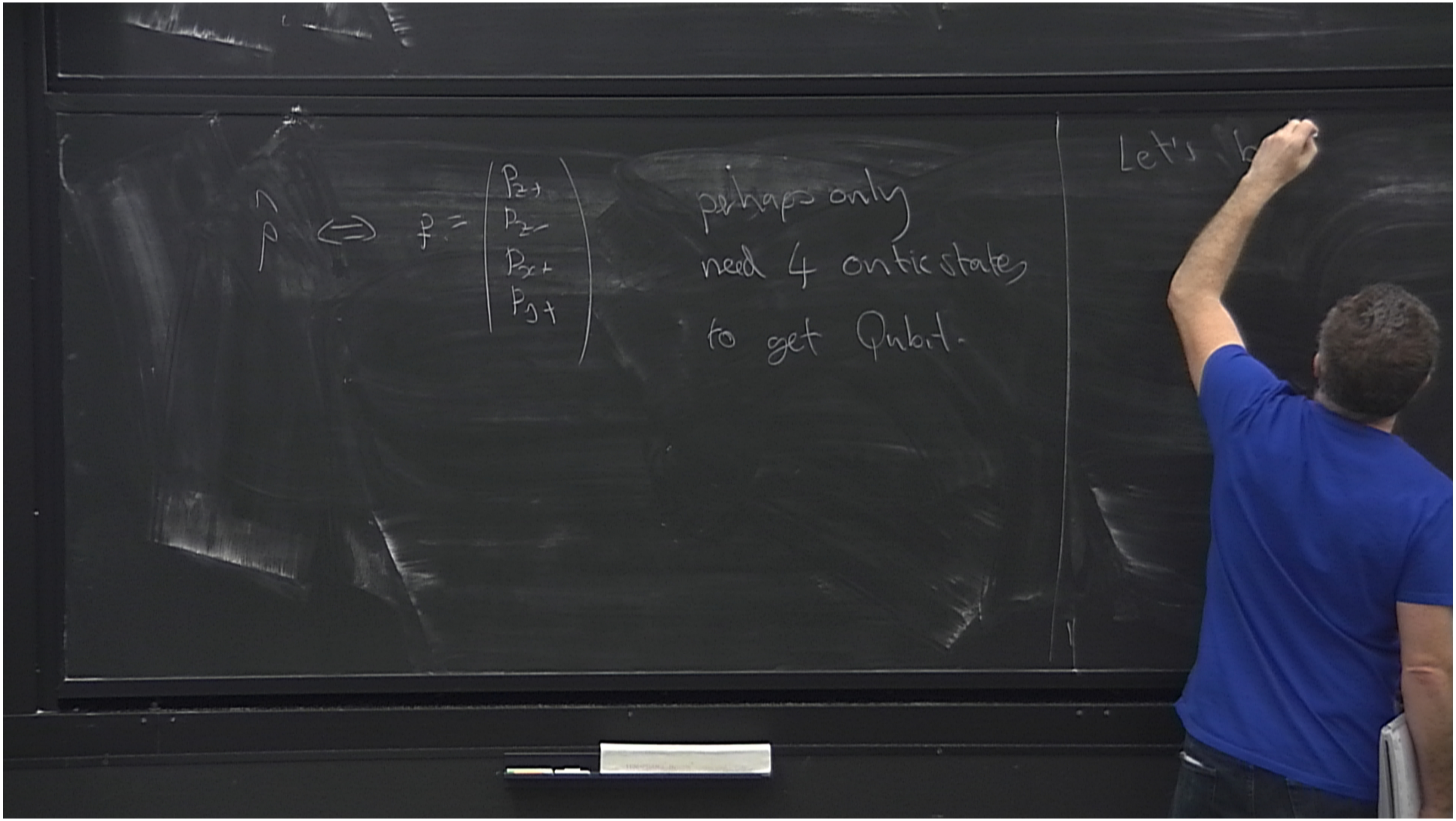
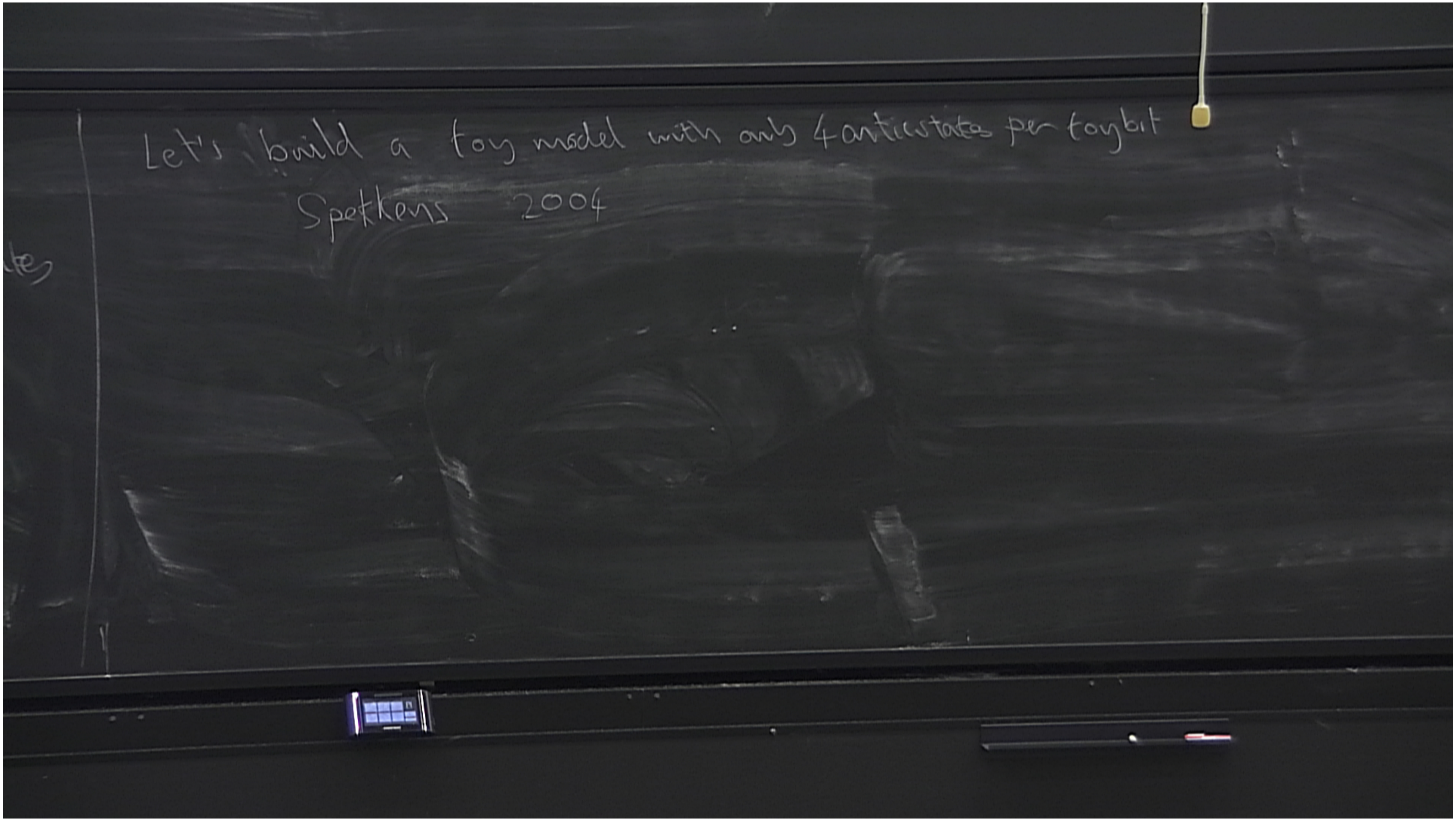
Title: 13/14 PSI - Foundations of Quantum Mechanics - Lecture 10

Date: Jan 20, 2014 11:30 AM

URL: http://pirsa.org/14010057

Abstract:


$\hat{\rho} \iff \vec{p} = \begin{pmatrix} p_{z+} \\ p_{z-} \\ p_{x+} \\ p_{y+} \end{pmatrix}$
perhaps only
need 4 ontic states
to get Qubit.
Let's b


Let's build a toy model with only 4 ontic states per toybit
Spekkens 2004

Let's build a toy model with only 4 ontic states per toy bit

Spekkens 2004 (LH 1999)

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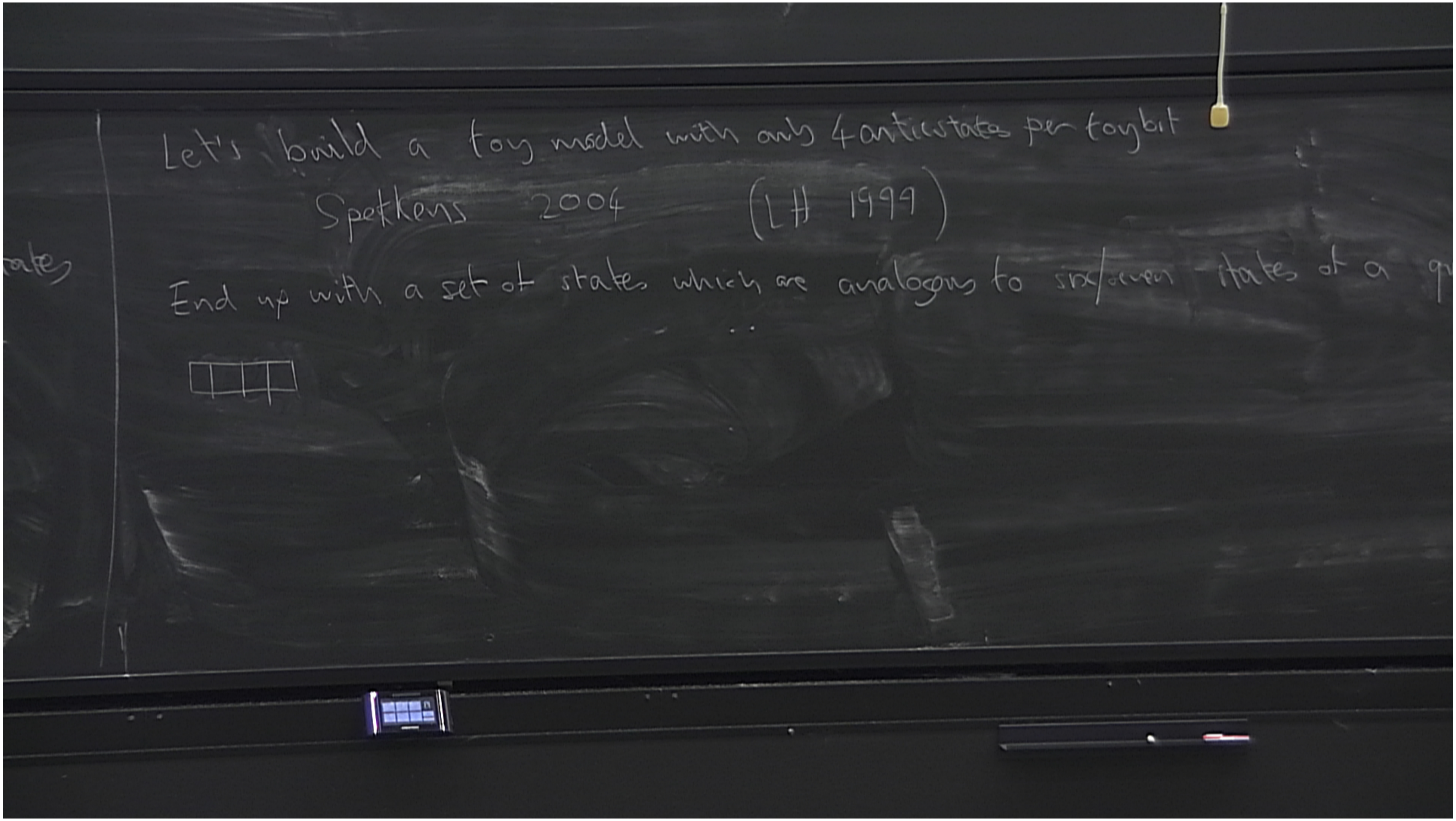
Spekkens 2004 (LH 1999)

End up with a set of states which are analogous to six/seven states of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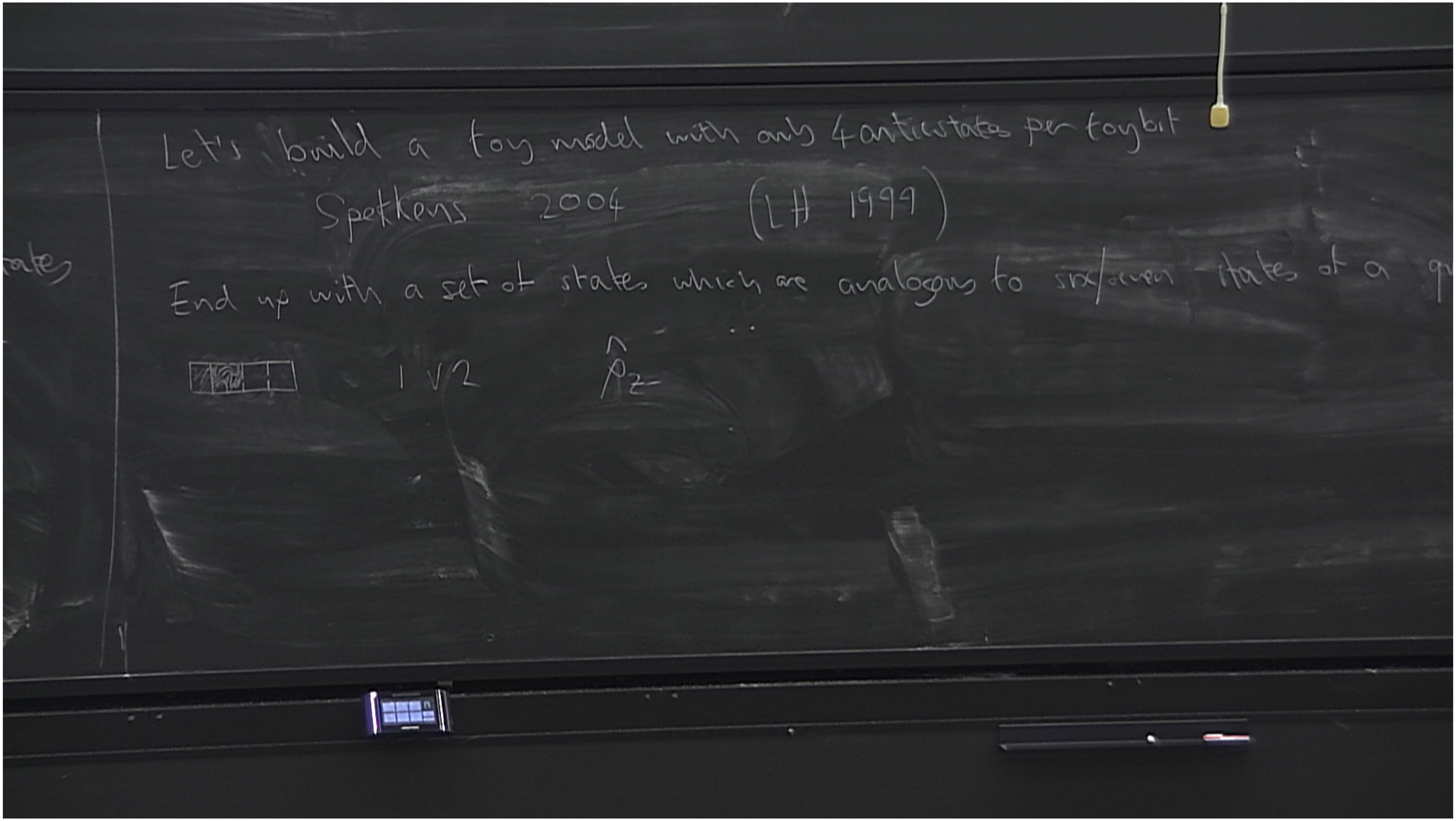
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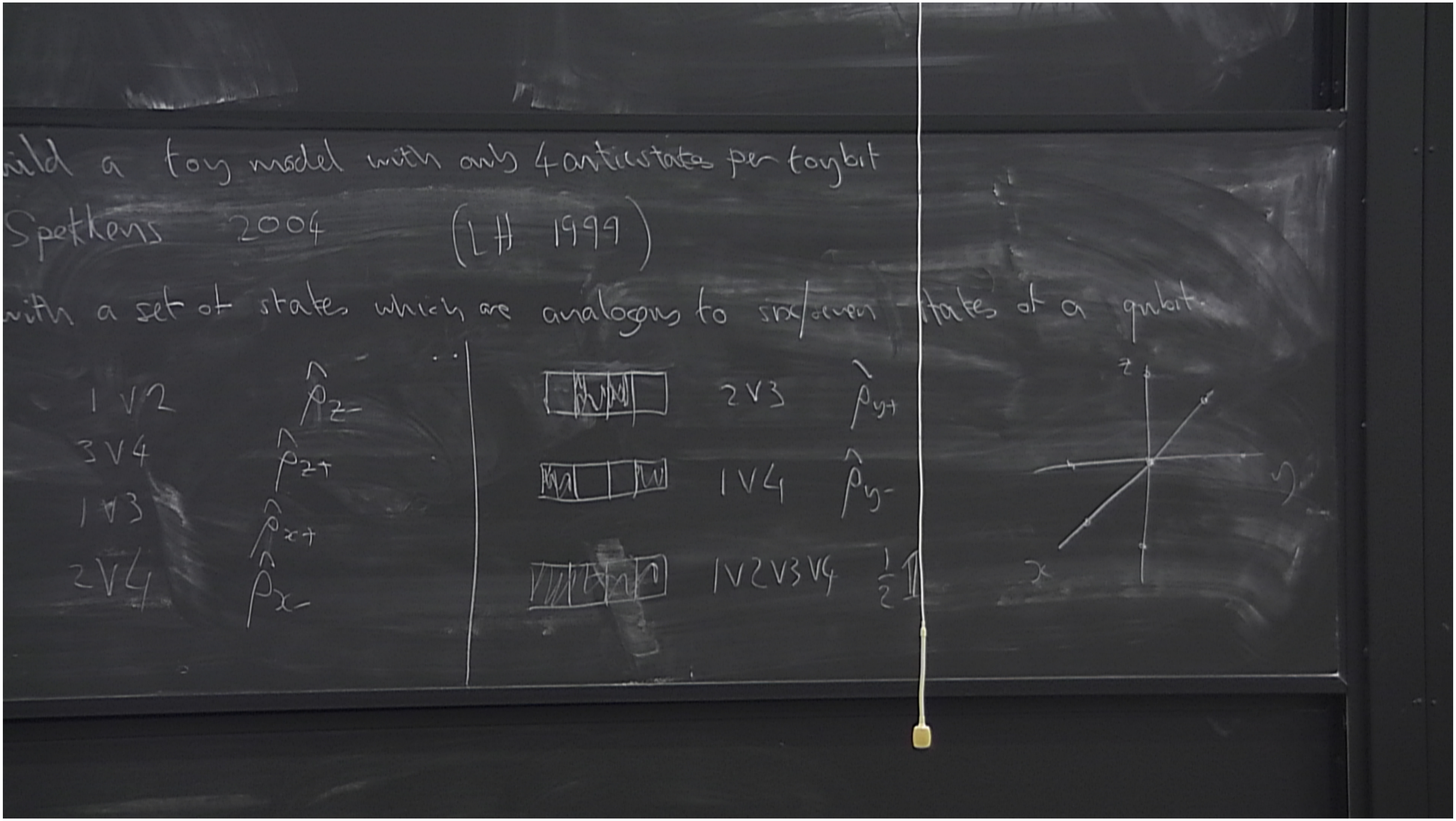
Spekkens 2004 (LH 1999)
End up with a set of states which are analogous to six/seven states of a q
1 √2

Let's build a toy model with only 4 ontic states per toybit

Spekkens 2004 (LH 1999)

End up with a set of states which are analogous to six/seven states of a qub

$1 \vee 2$	$\hat{\rho}_{z-}$
$3 \vee 4$	$\hat{\rho}_{z+}$
$1 \vee 3$	$\hat{\rho}_{x+}$
$2 \vee 4$	$\hat{\rho}_{x-}$
$2 \vee 3$	$\hat{\rho}_{y+}$
$1 \vee 4$	$\hat{\rho}_{y-}$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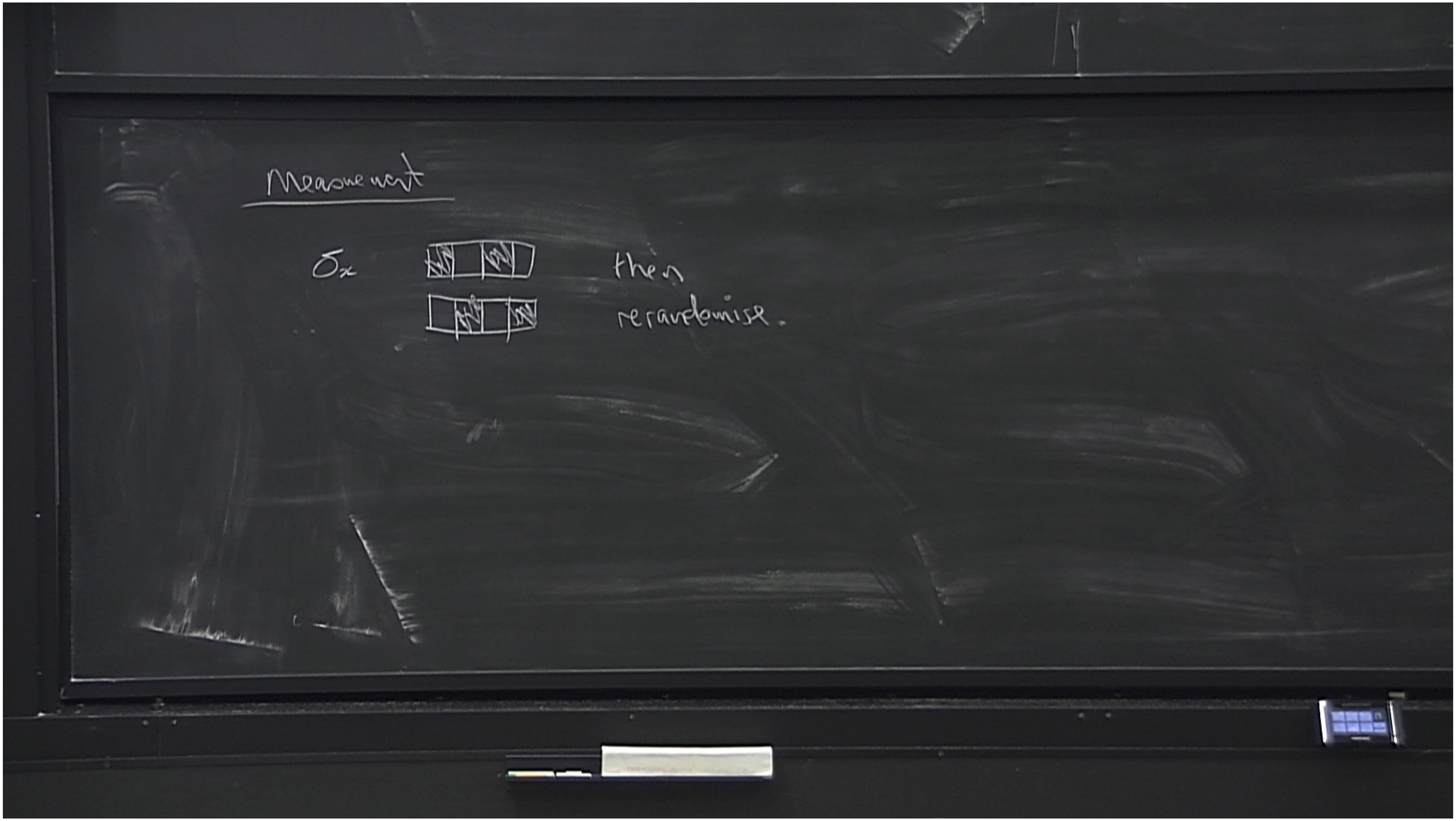
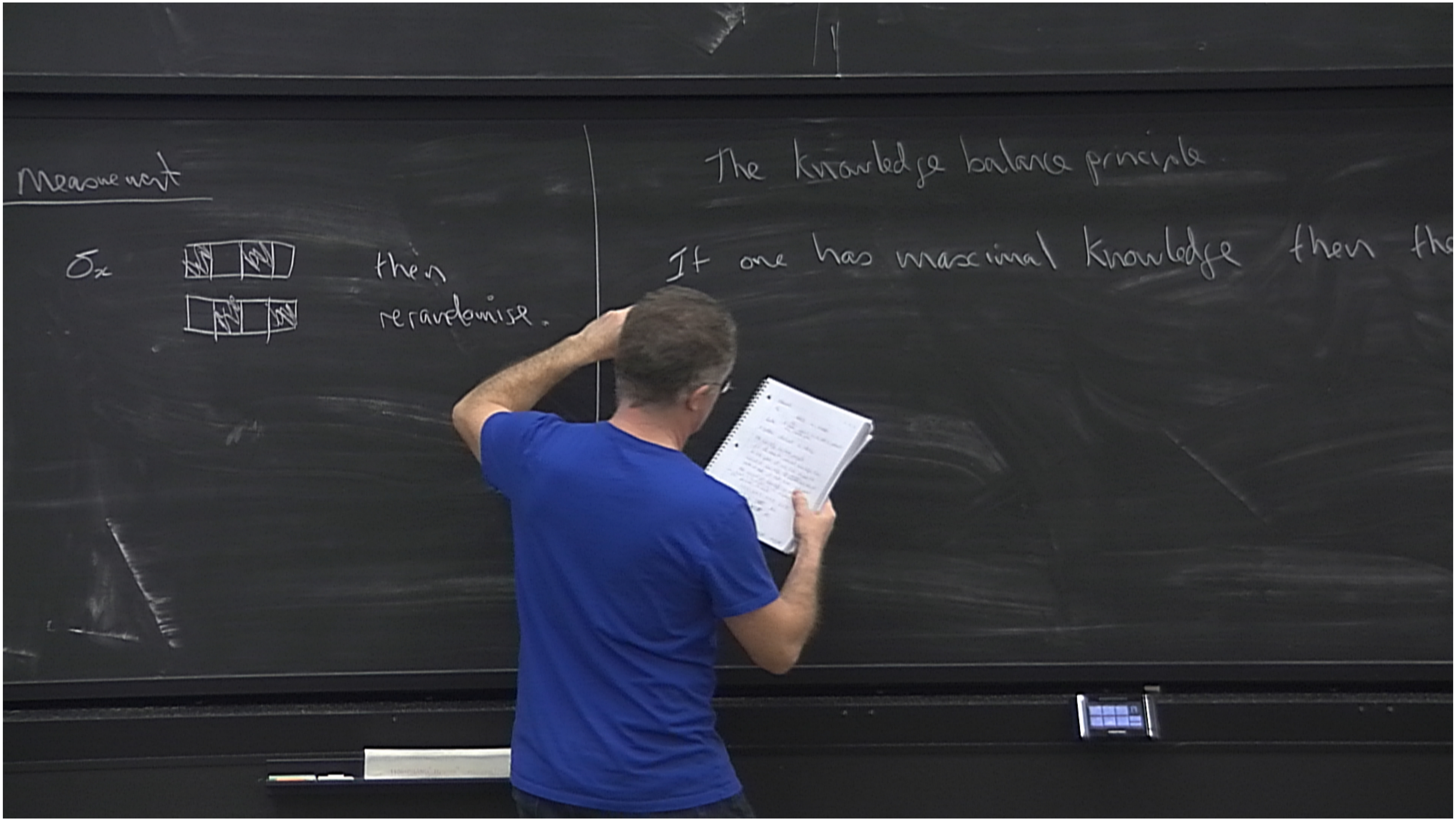
Spekkens 2004 (LH 1999)
with a set of states which are analogous to six/seven states of a qubit
1 V 2 $\hat{\rho}_{z-}$
3 V 4 $\hat{\rho}_{z+}$
1 V 3 $\hat{\rho}_{x+}$
2 V 4 $\hat{\rho}_{x-}$
2 V 3 $\hat{\rho}_{y+}$
1 V 4 $\hat{\rho}_{y-}$
1 V 2 V 3 V 4 $\frac{1}{2}$
z
y
x


Measurement
σx
then
rerandomise.


Measurement
σx
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The knowledge balance principle
If one has maximal knowledge then

The knowledge balance principle

If one has maximal knowledge then the amount of knowledge one possesses about the ontic state is equal to the amount of knowledge one lacks.

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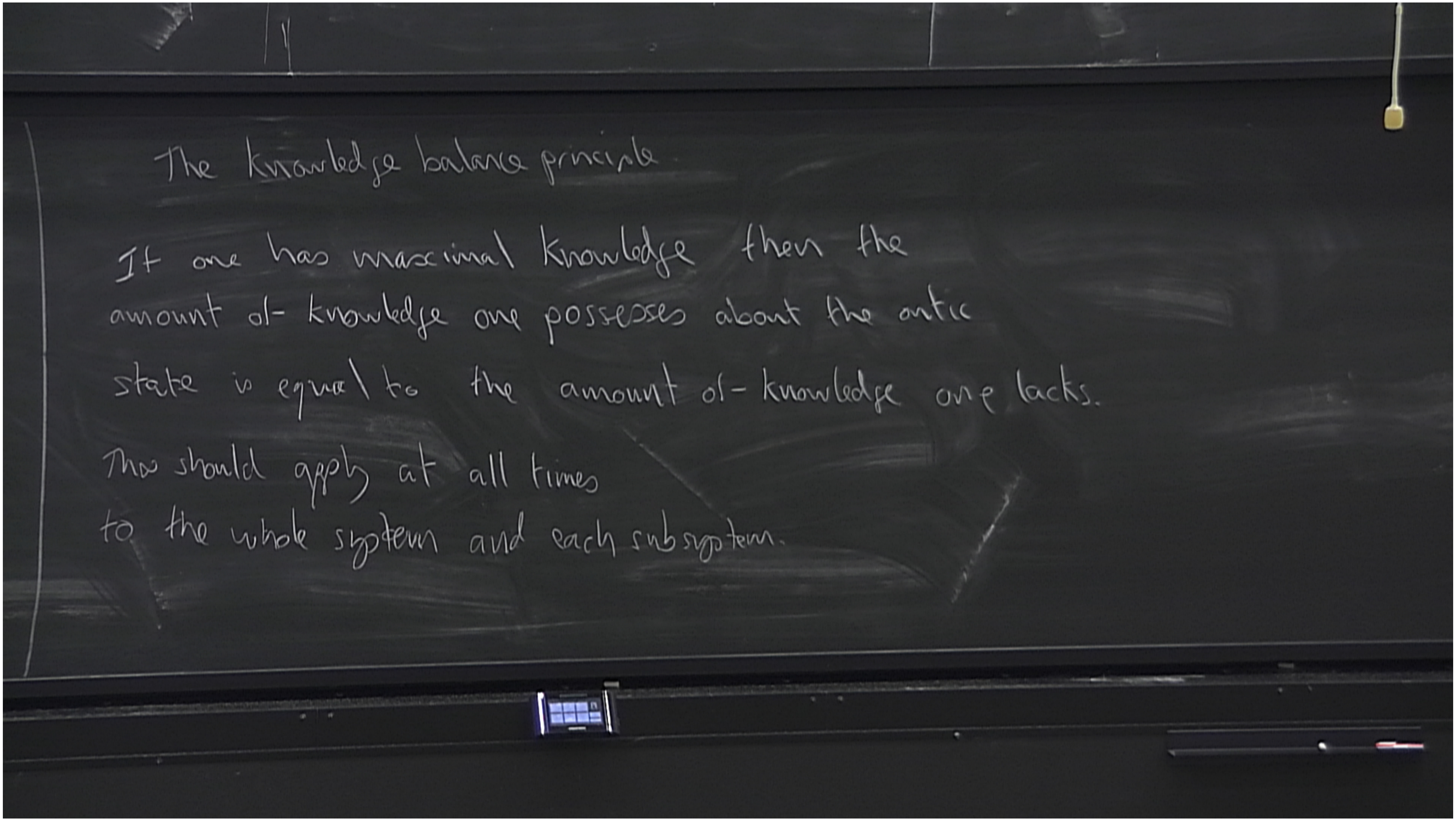
This should apply at all times to the whole system and each subsystem.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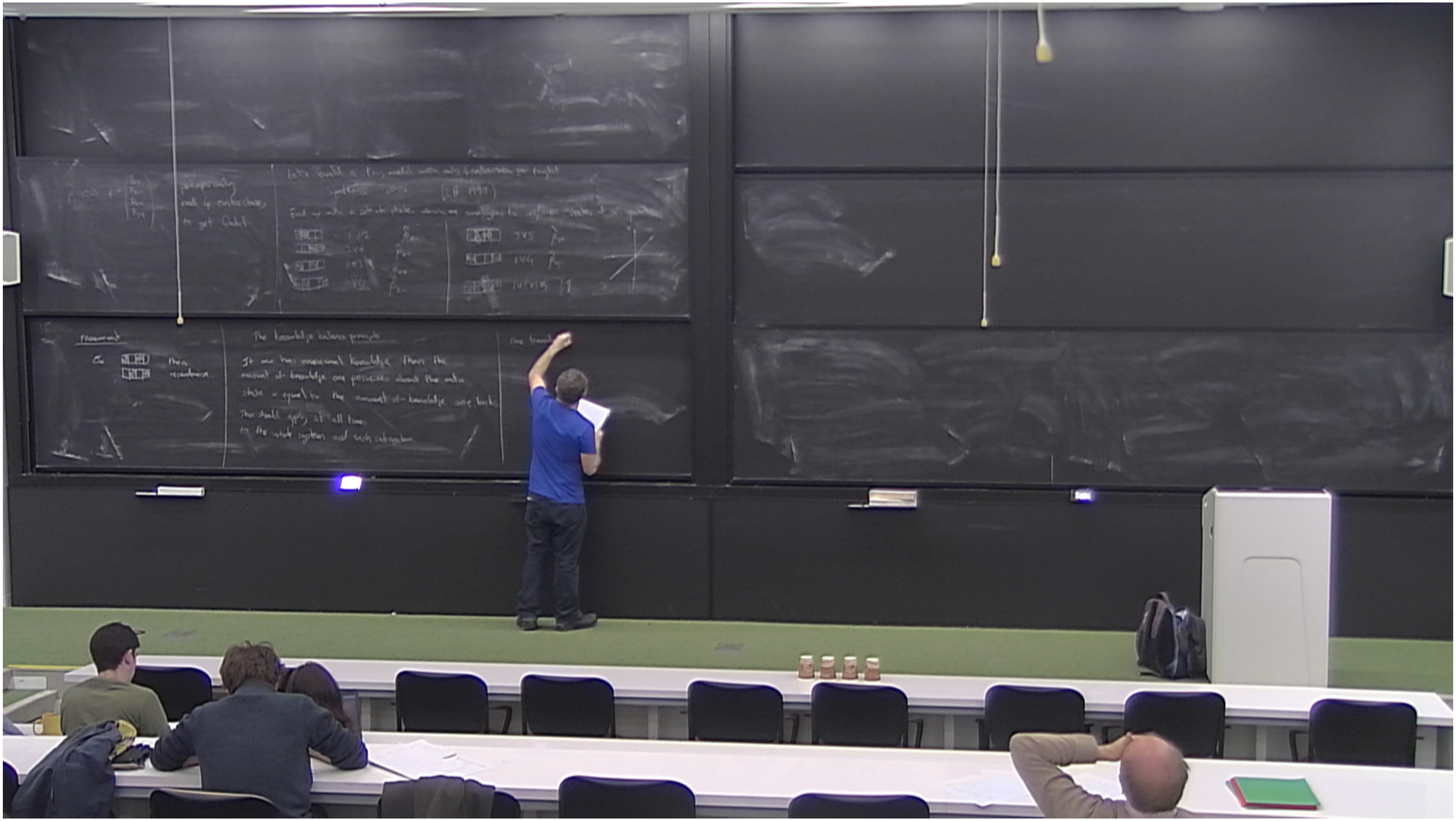
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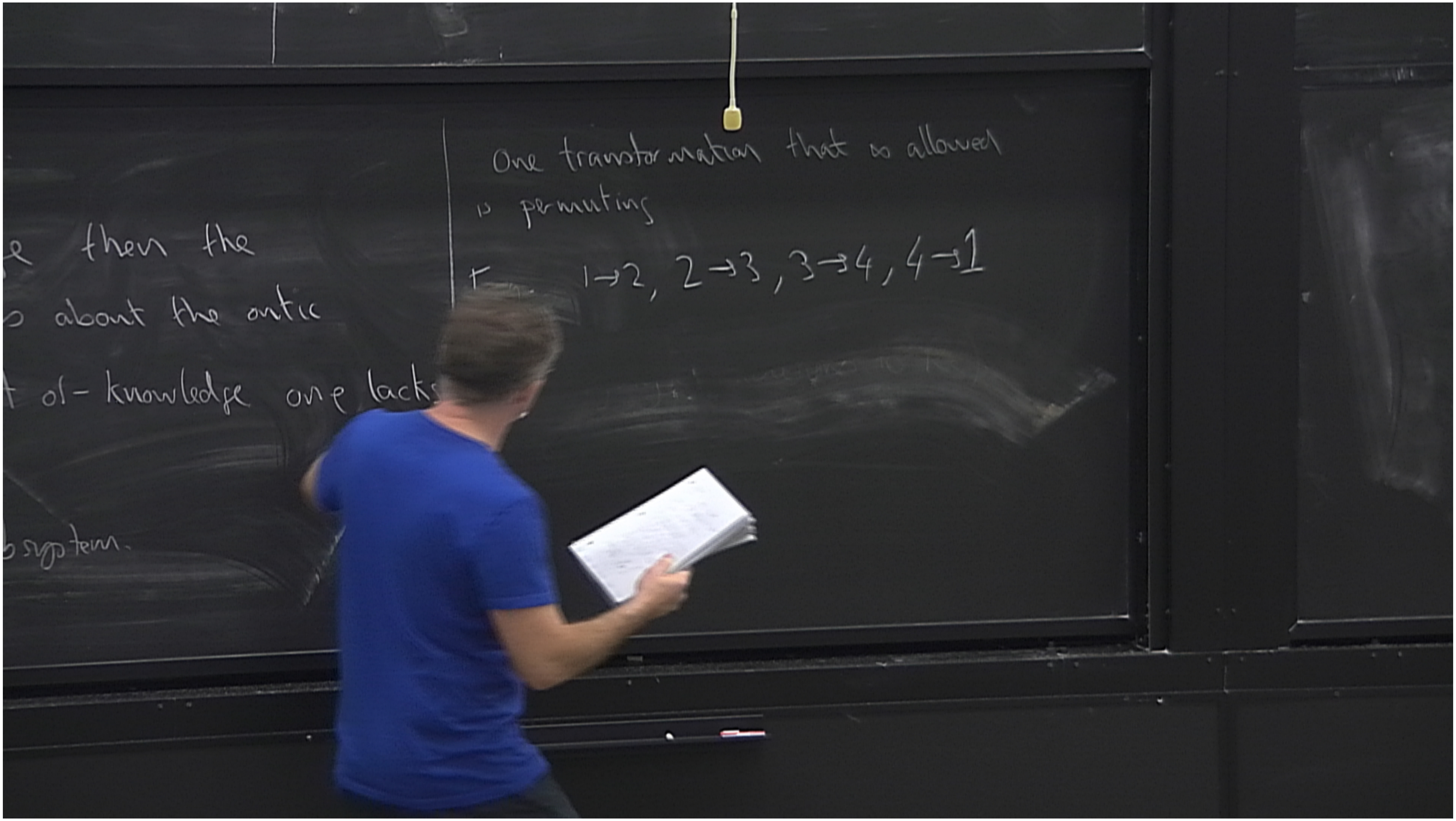
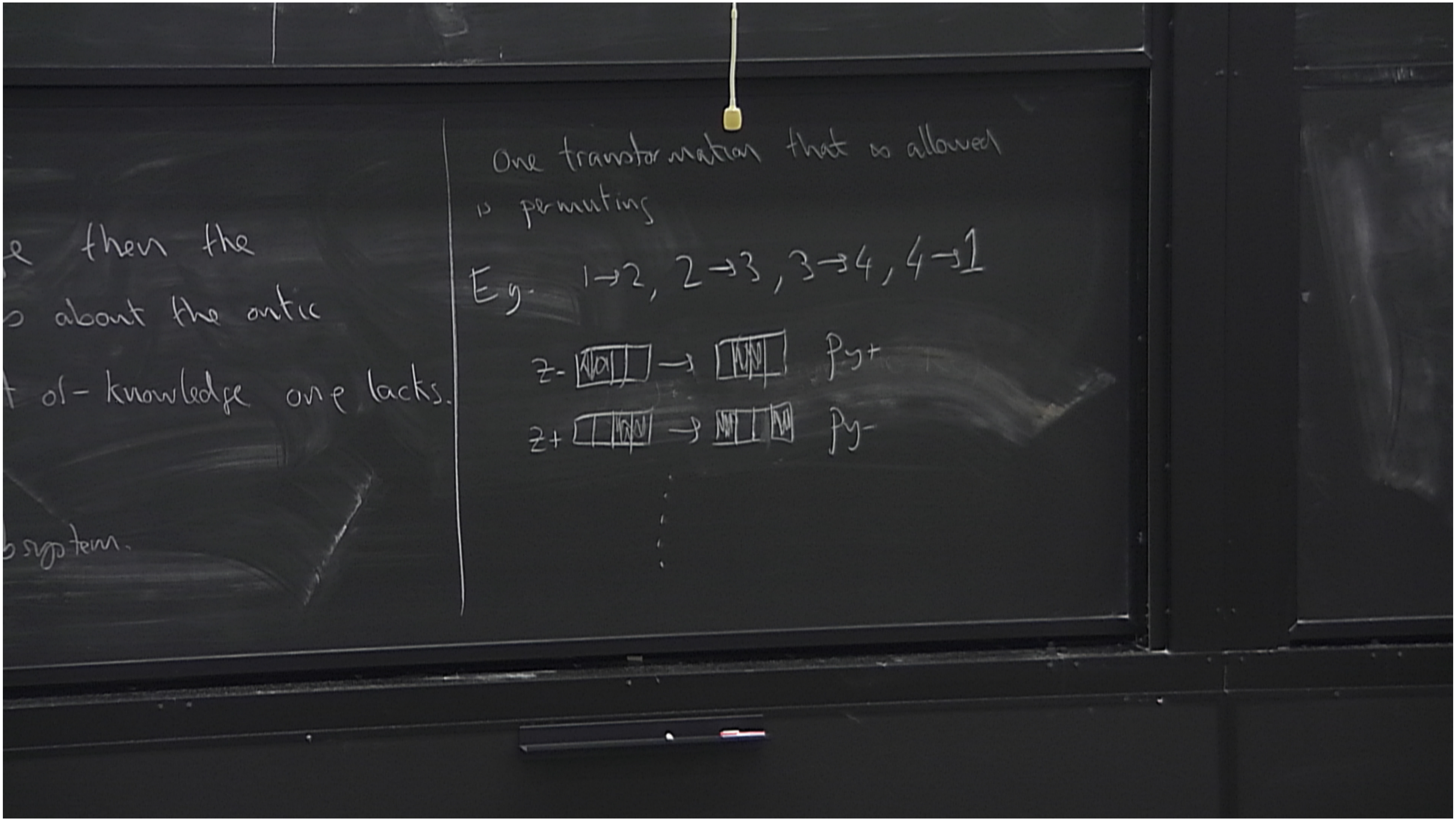

then the
about the ontic
of-knowledge one lacks
system.
One transformation that is allowed
is permuting
1→2, 2→3, 3→4, 4→1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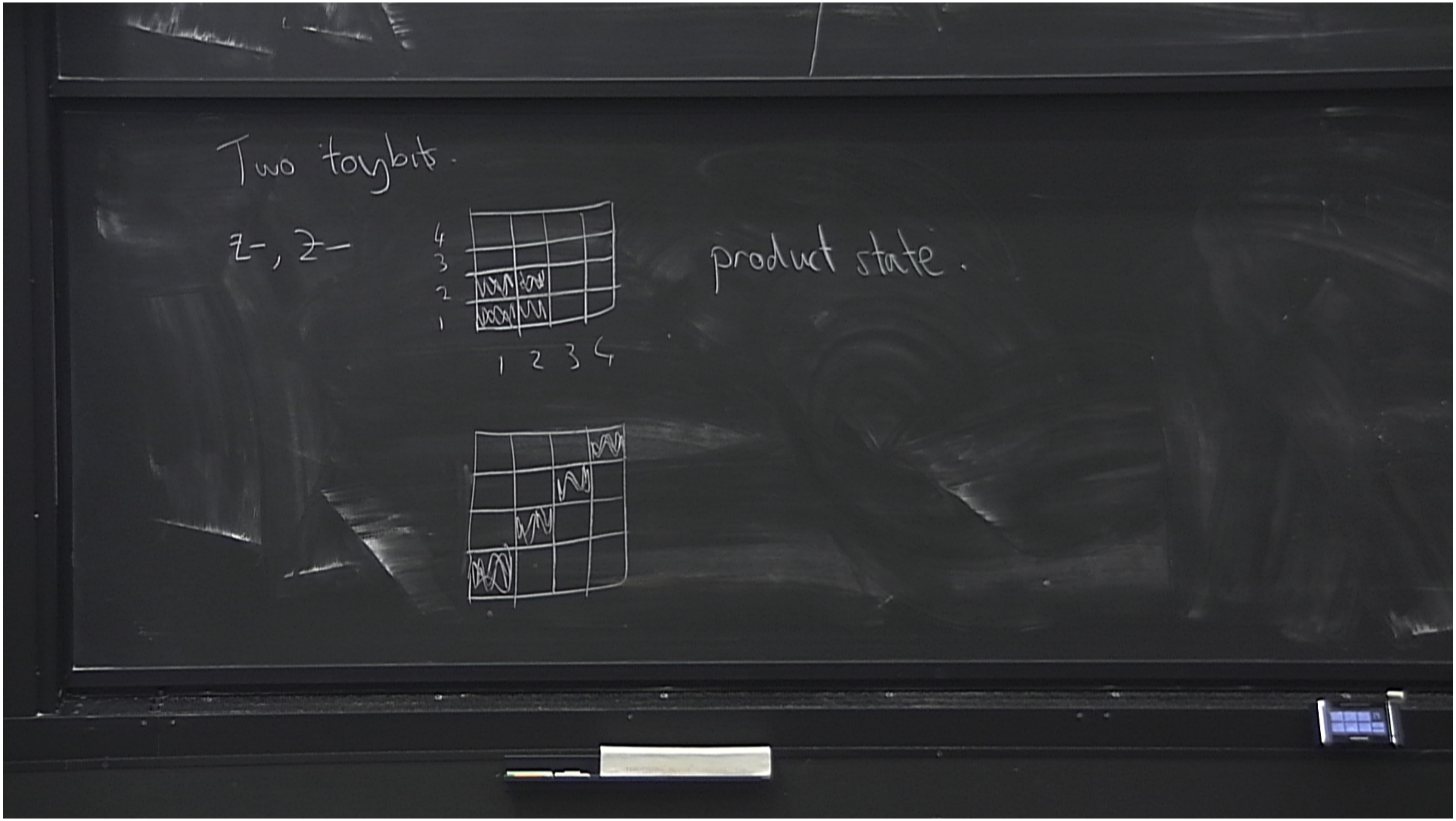
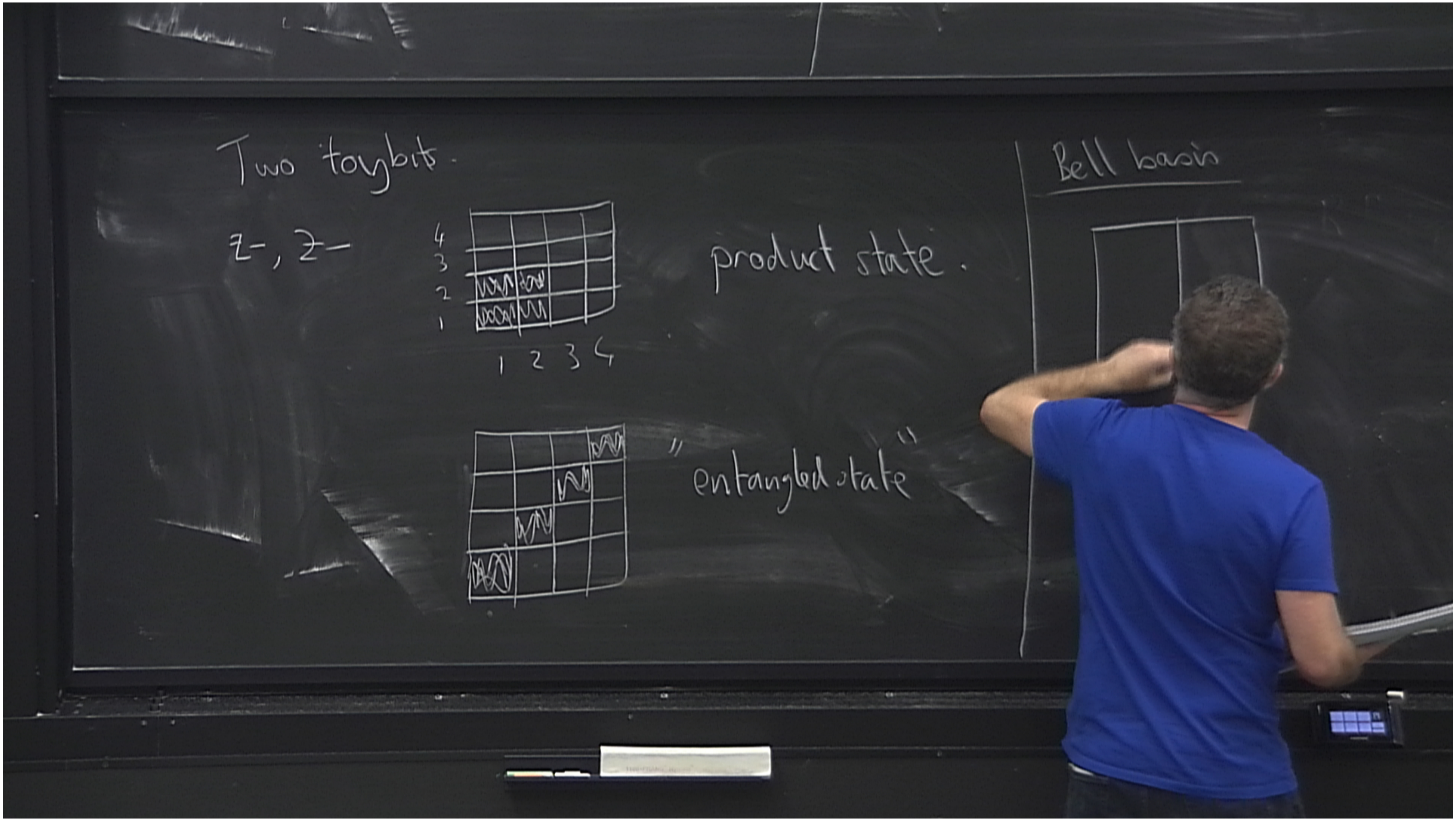
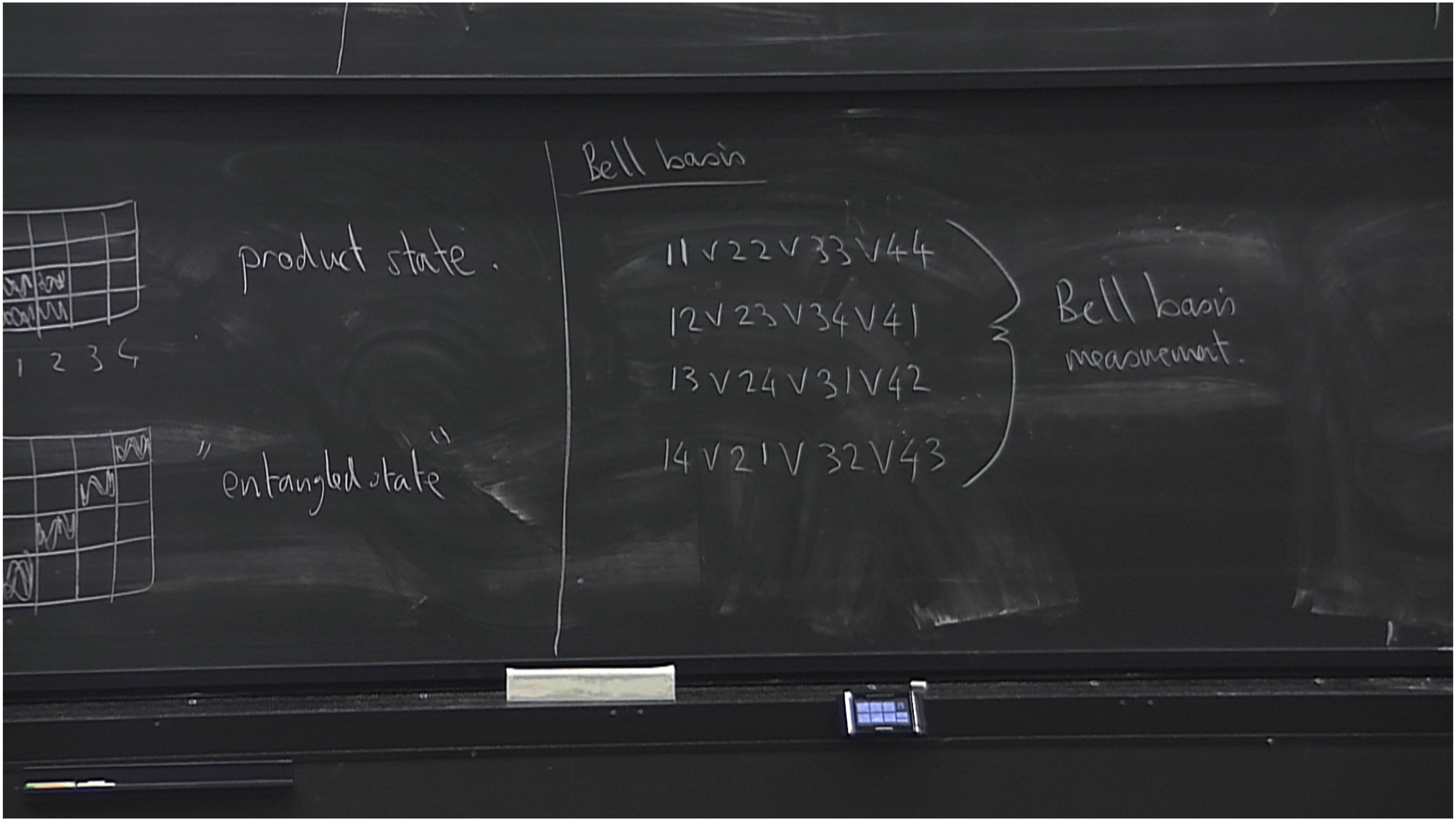
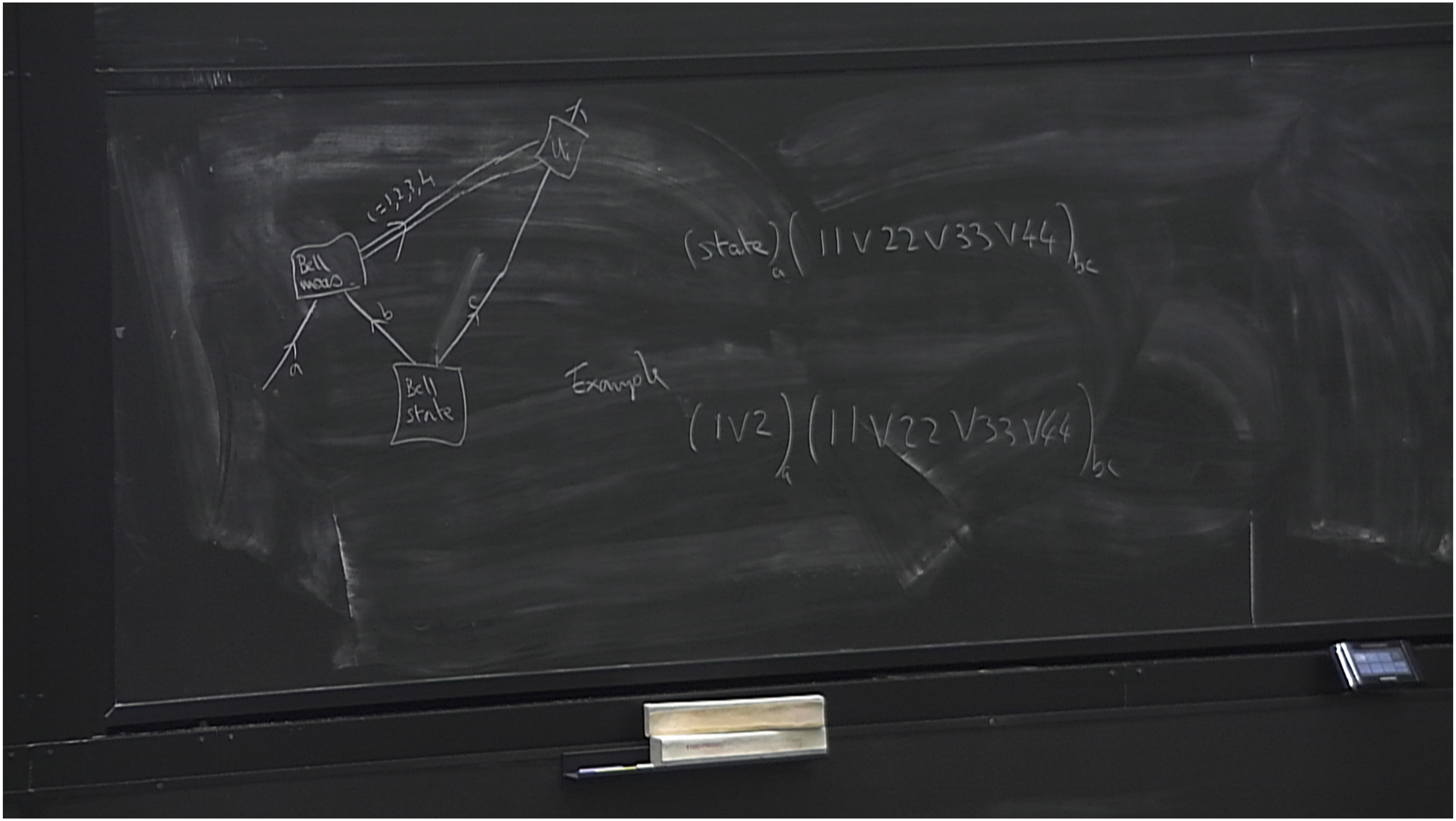
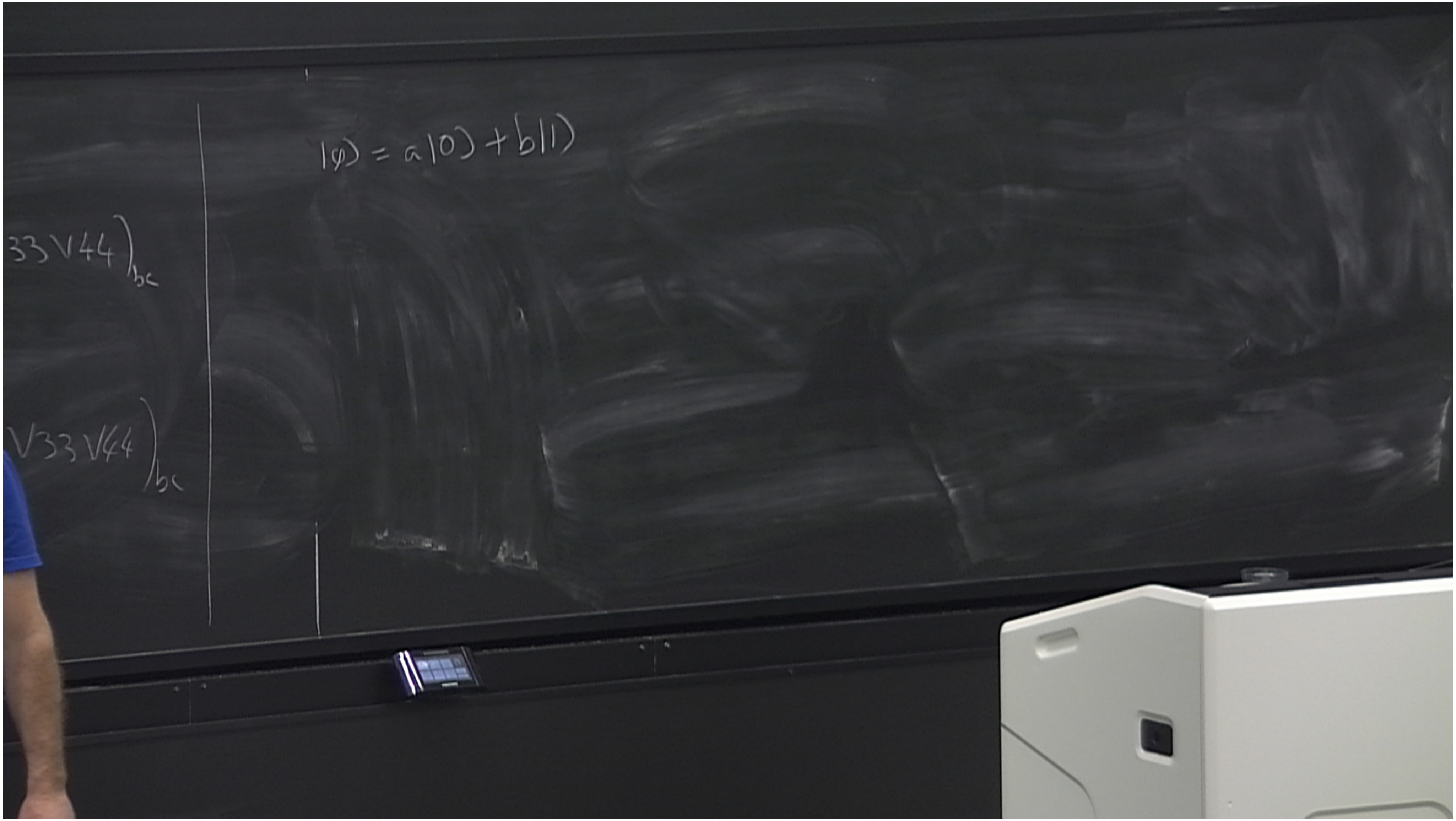
One transformation that is allowed
is permuting
E.g. 1→2, 2→3, 3→4, 4→1
Z- → Py+
Z+ → Py-

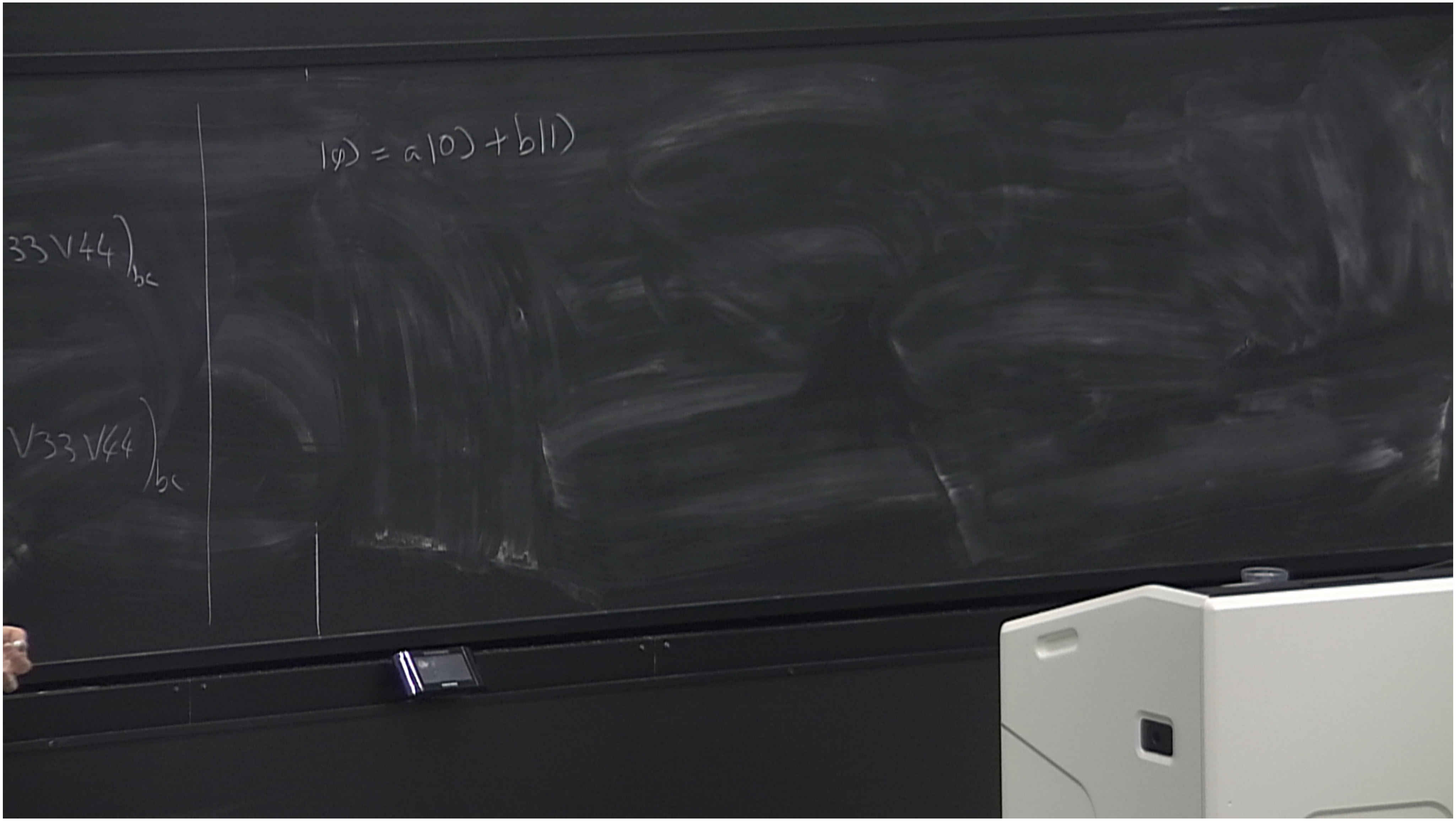

Two toybits.
Z−, Z−
product state.
1 2 3 4

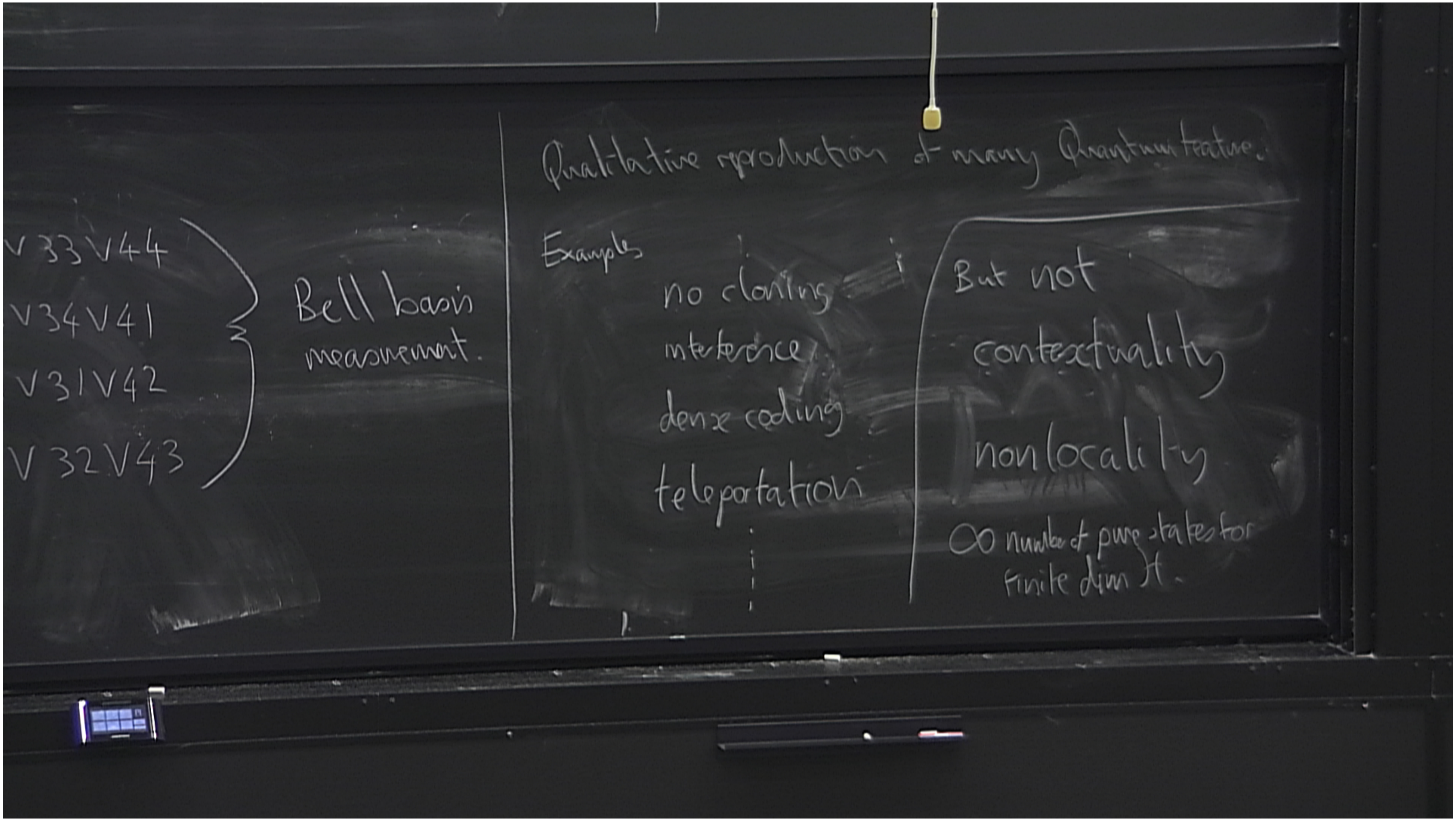

Two toybits.
Z−, Z−
4
3
2
1
1 2 3 4
product state.
"entangled state"
Bell basis

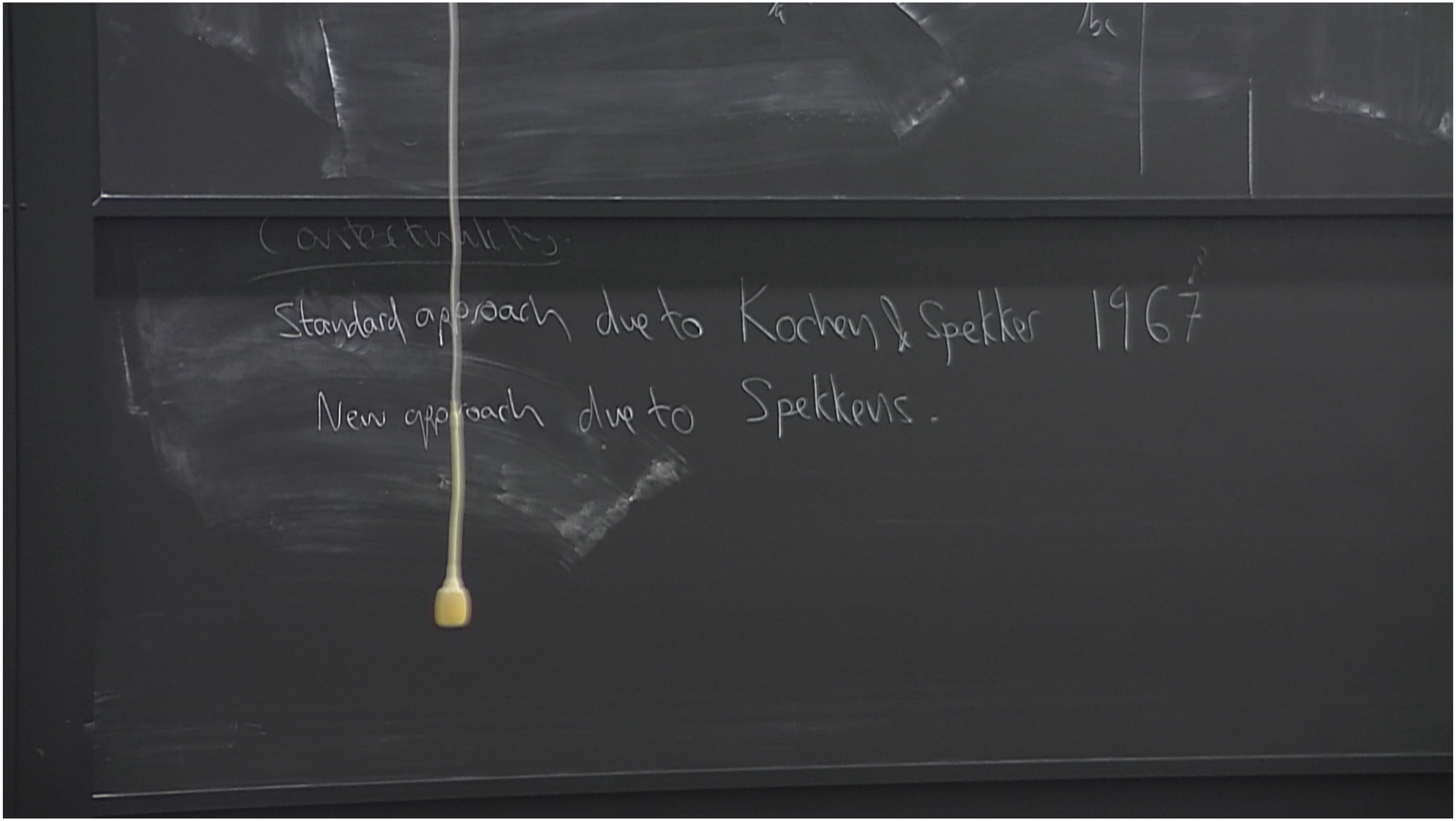

Bell basis
product state.
1 2 3 4
"entangled state"
11 ∨ 22 ∨ 33 ∨ 44
12 ∨ 23 ∨ 34 ∨ 41
13 ∨ 24 ∨ 31 ∨ 42
14 ∨ 21 ∨ 32 ∨ 43
Bell basis measurement.


Bell meas
i=1,2,3,4
U_i
a
b
c
Bell state
$(\text{state})_a (11 \vee 22 \vee 33 \vee 44)_{bc}$
Example
$(1 \vee 2)_a (11 \vee 22 \vee 33 \vee 44)_{bc}$


|φ) = a|0) + b|1)


|φ) = a|0) + b|1)
33V44)bc
V33V44)bc


V33V44
V34V41
V31V42
V32V43
Bell basis measurement.
Qualitative reproduction of many Quantum features.
Examples
no cloning
interference
dense coding
teleportation
But not
contextuality
nonlocality
∞ number of pure states for finite dim H.

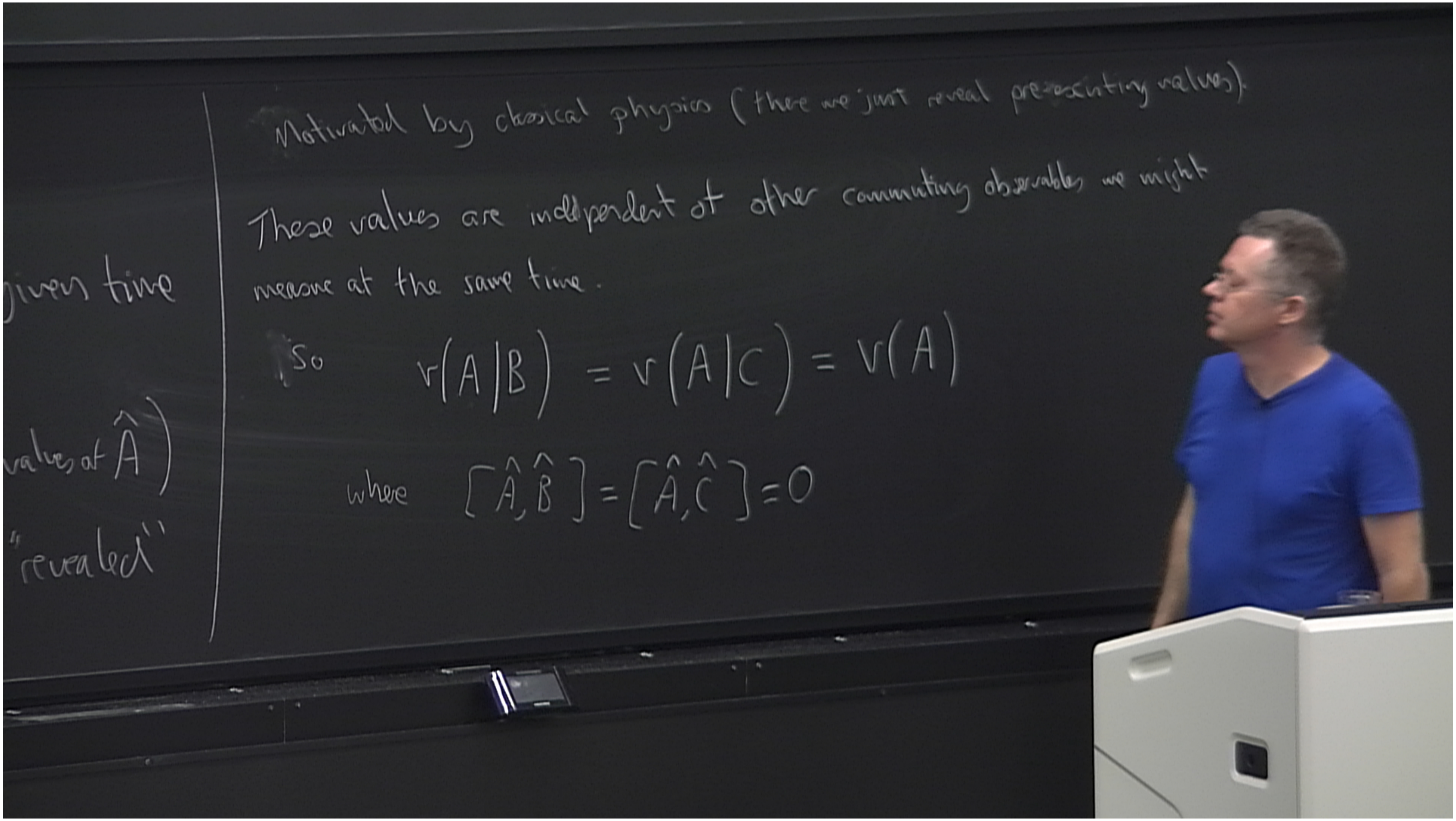

Contextuality.
Standard approach due to Kochen & Specker 1967
New approach due to Spekkens.

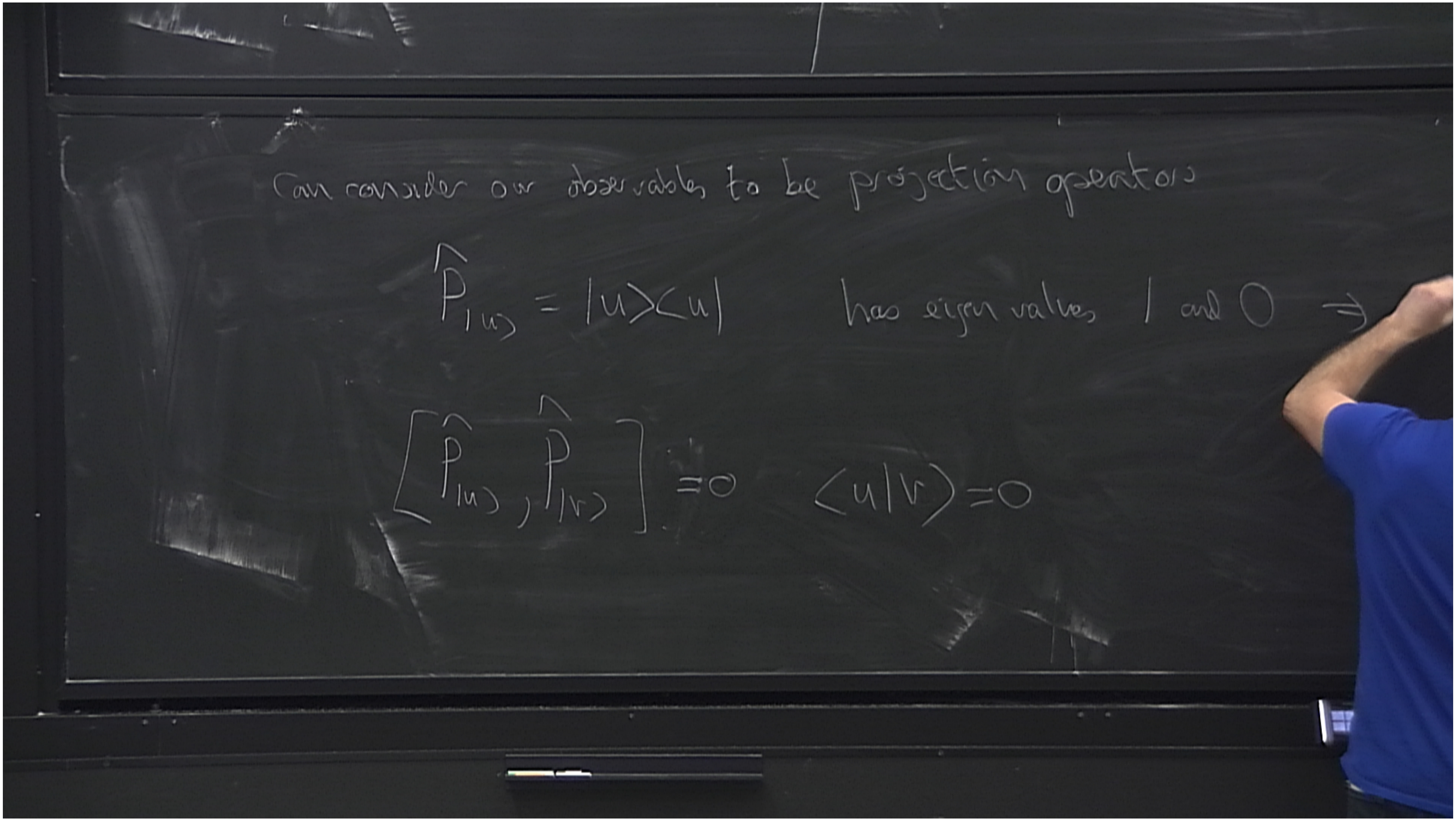
Definition of noncontextuality.

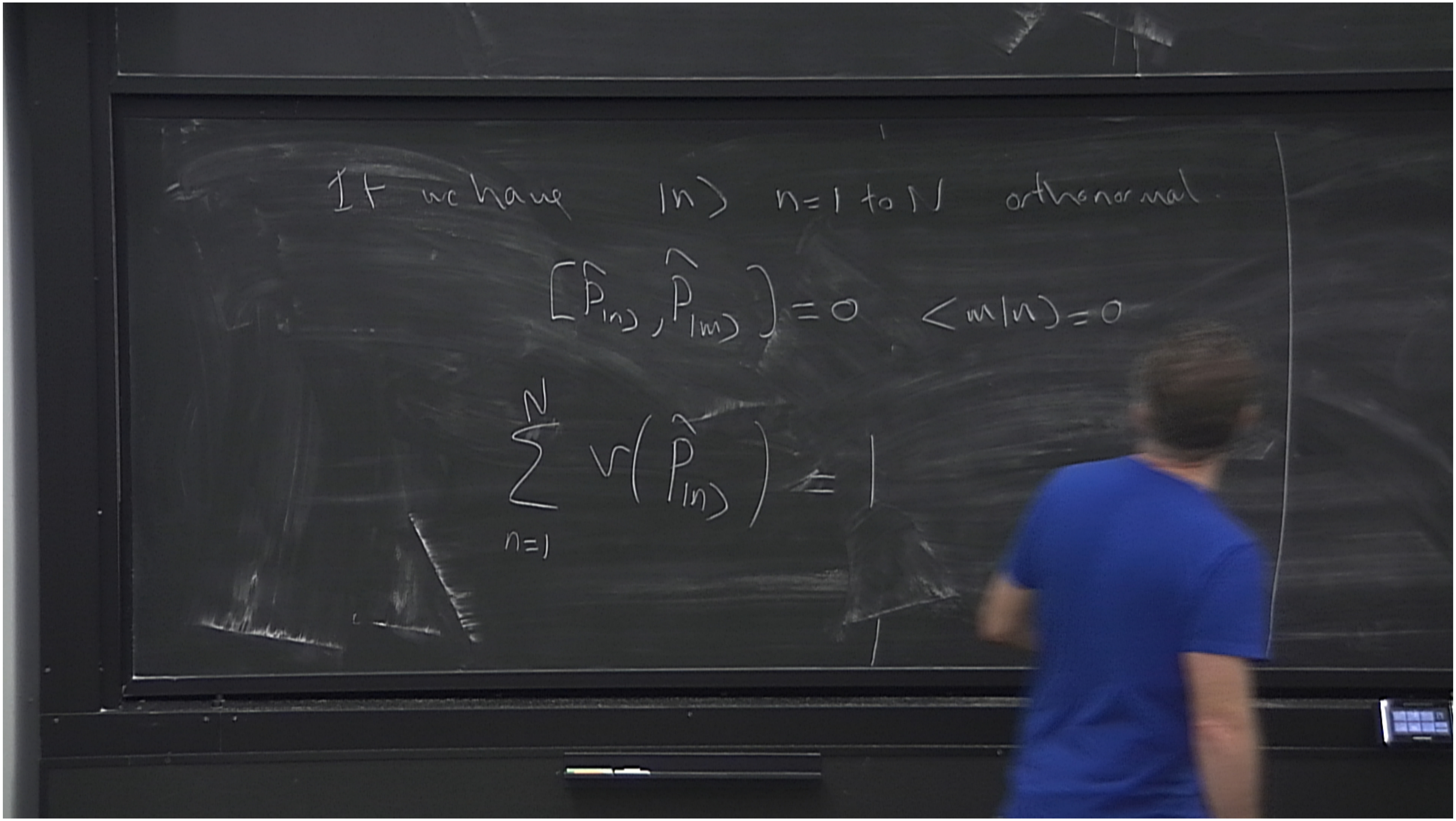
In each run of experiment at a given time there is an assigned value

$$v(A) \in \{ \text{set of eigenvalues of } \hat{A})$$

and this is the value that would be "revealed" if we measure $\hat{A}$.


given time
values of $\hat{A}$)
"revealed"
Motivated by classical physics (there we just reveal pre-existing values).
These values are independent of other commuting observables we might measure at the same time.
So $v(A|B) = v(A|C) = v(A)$
where $[\hat{A}, \hat{B}] = [\hat{A}, \hat{C}] = 0$


Can consider our observables to be projection operators
$\hat{P}_{|u\rangle} = |u\rangle\langle u|$ has eigenvalues 1 and 0 ⇒
$[\hat{P}_{|u\rangle}, \hat{P}_{|v\rangle}] = 0$ $\langle u|v\rangle = 0$

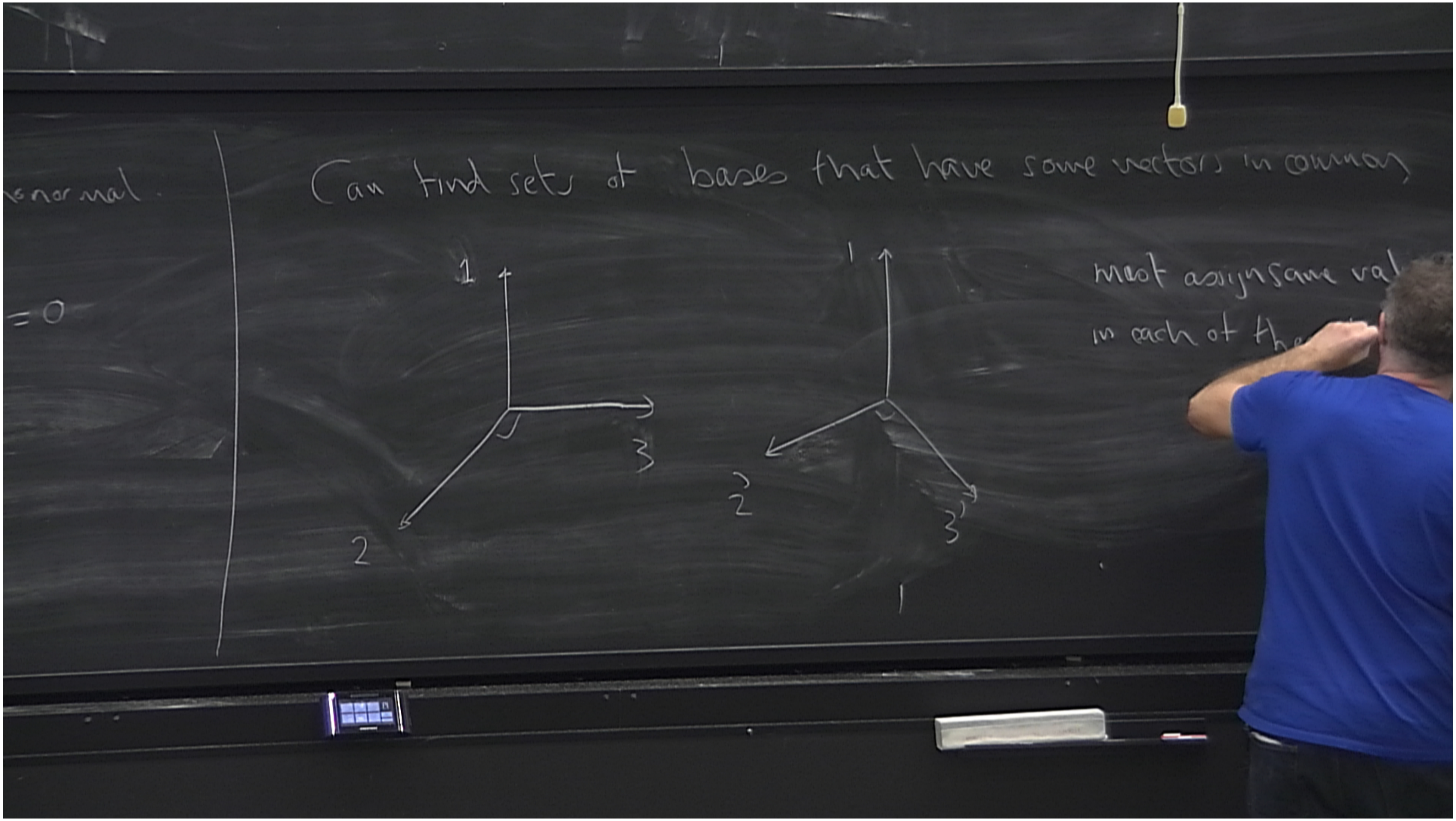

If we have $|n\rangle$ $n=1$ to N orthonormal.
$[\hat{P}_{|n\rangle}, \hat{P}_{|m\rangle}] = 0$ $\langle m|n\rangle = 0$
$\sum_{n=1}^{N} v(\hat{P}_{|n\rangle}) = 1$

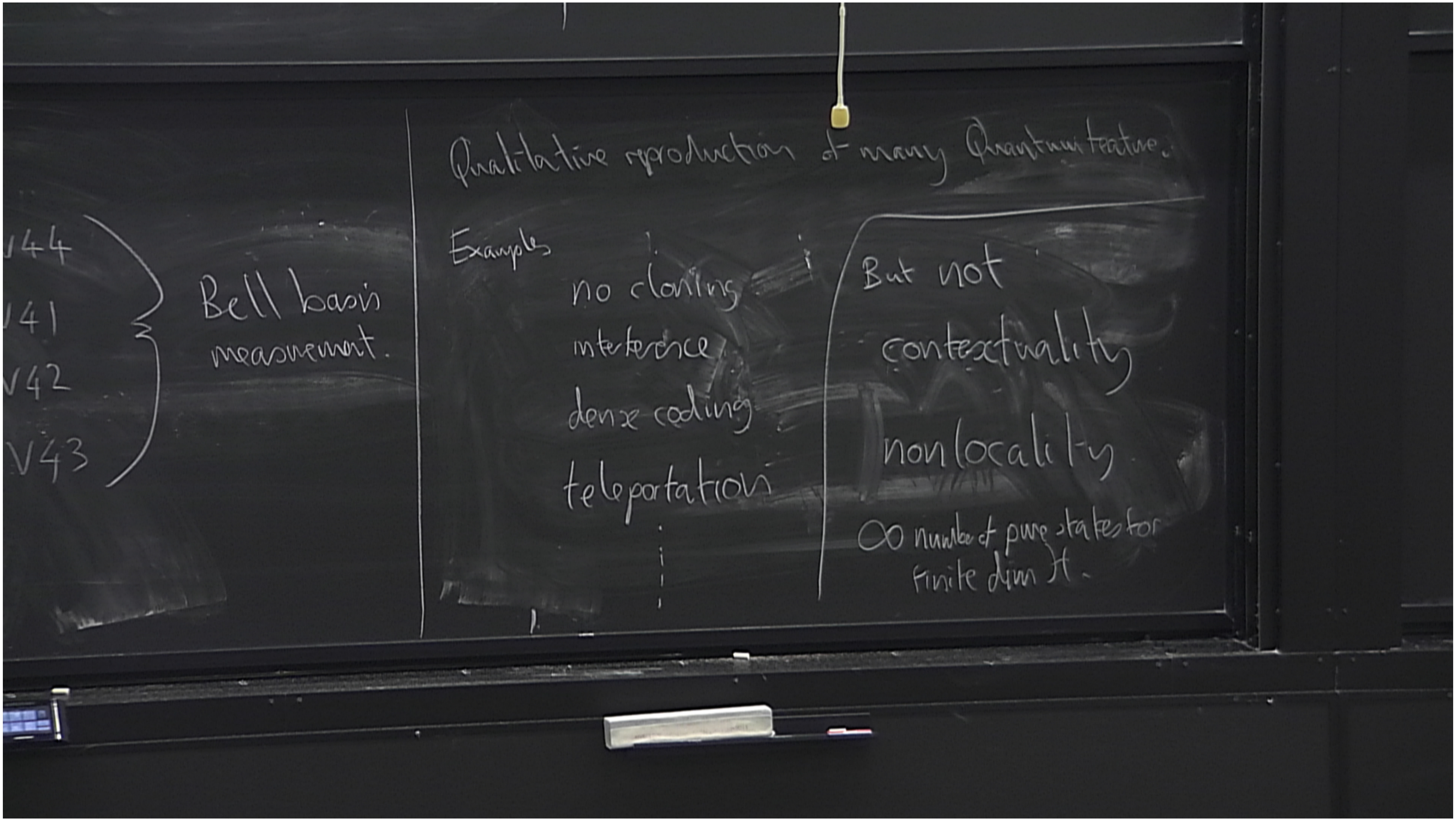
If we have $|n\rangle$ $n=1$ to N orthonormal.

$$[\hat{P}_{|n\rangle}, \hat{P}_{|m\rangle}] = 0 \qquad \langle m|n\rangle = 0$$

$$\sum_{n=1}^{N} \nu(\hat{P}_{|n\rangle}) \leq 1$$

Can


normal.
= 0
Can find sets of bases that have some vectors in common
1
2
3
1
2
3
must assign same val
in each of the



Qualitative reproduction of many Quantum feature.
V42
V43
Bell basis measurement.
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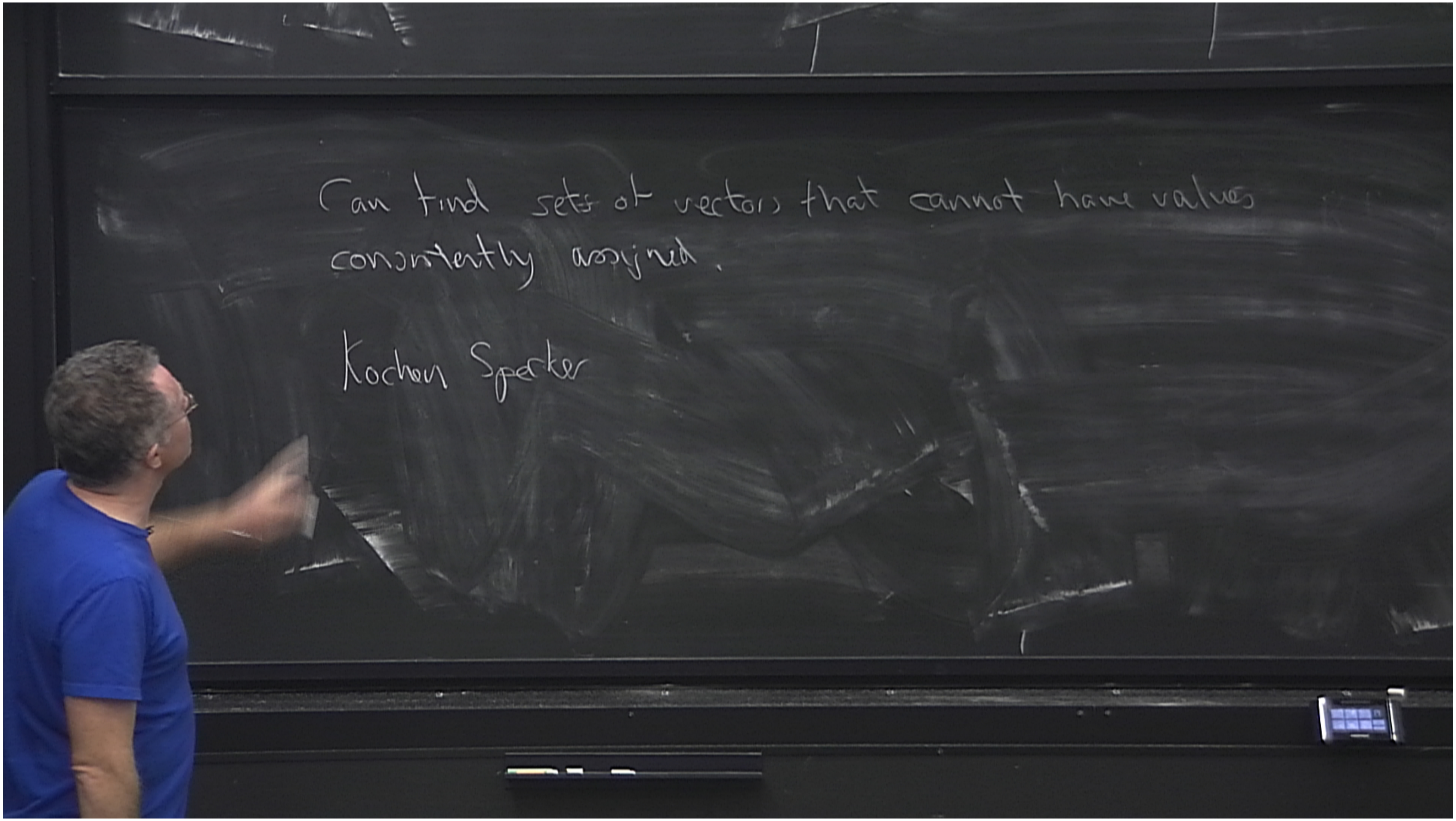
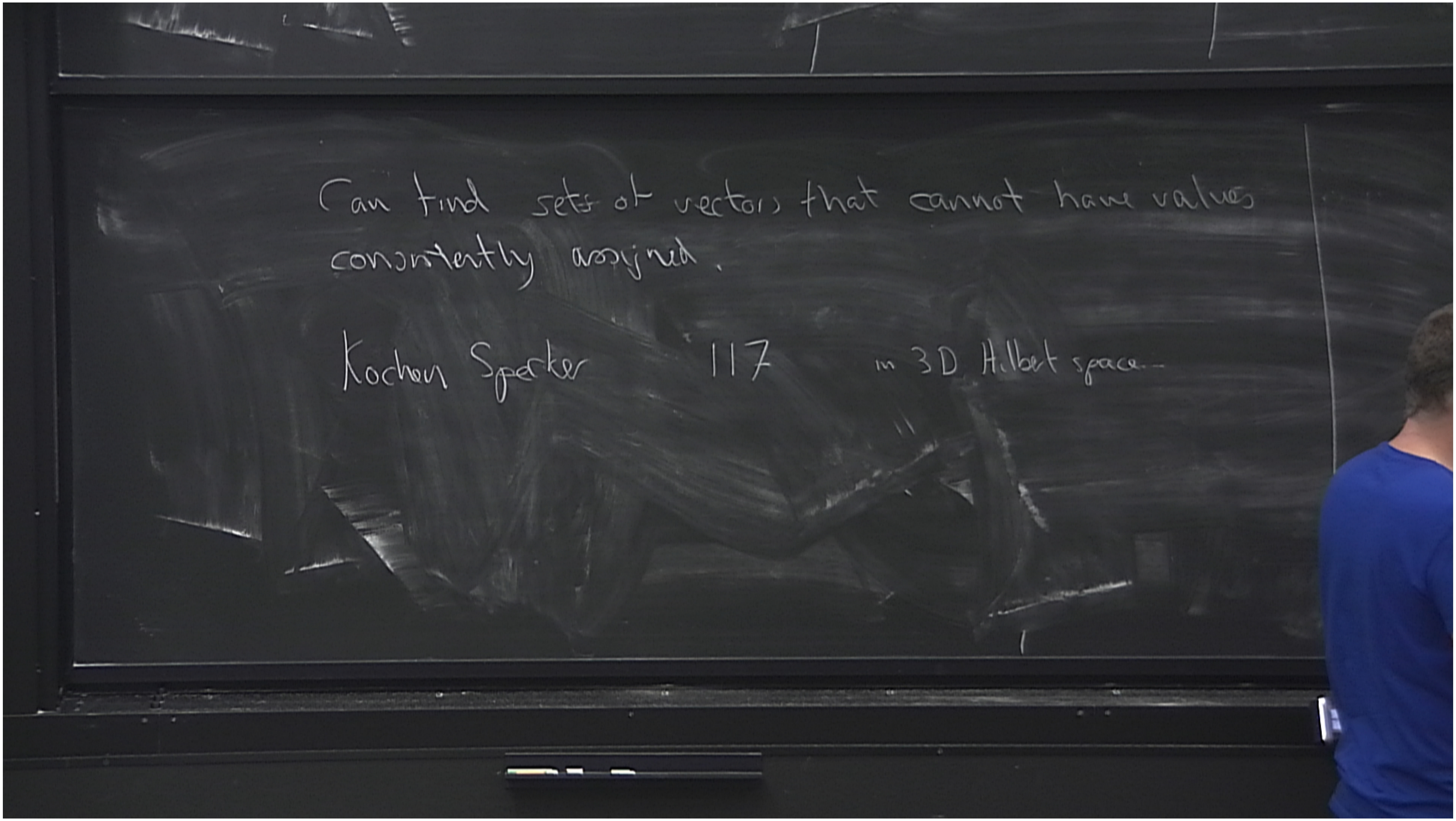
∞ number of pure states for finite dim H.


Can find sets of vectors that cannot have values
consistently assigned.
Kochen Specker


Can find sets of vectors that cannot have values
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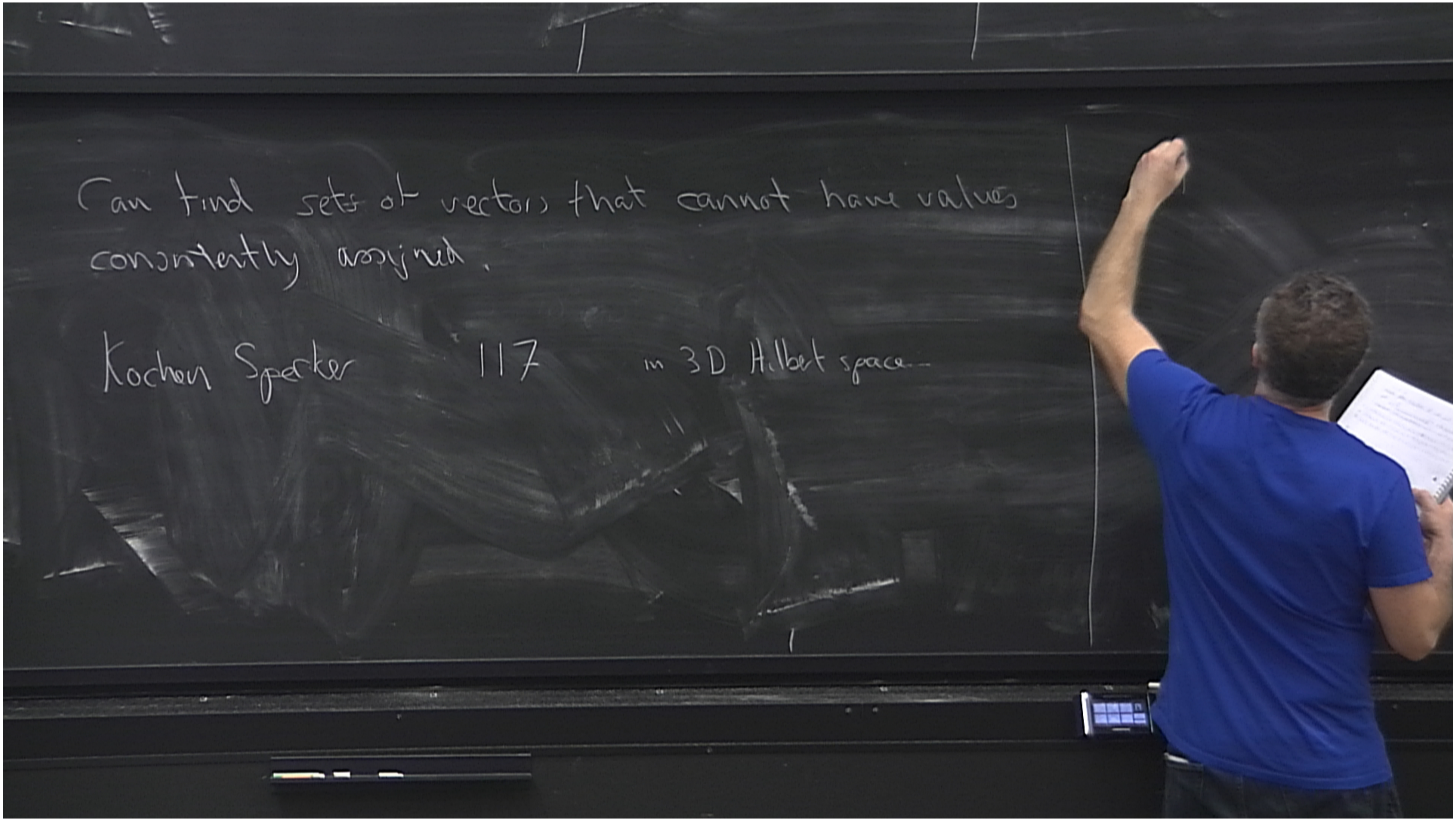
Kochen Specker 117 in 3D Hilbert space...


Can find sets of vectors that cannot have values
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Kochen Specker 117 in 3D Hilbert space...

Adán Cabello 18 vectors.

1. $v(0,0,0,1) + v(0,0,1,0) + v(1,1,0,0) + v(1,-1,0,0) = 1$

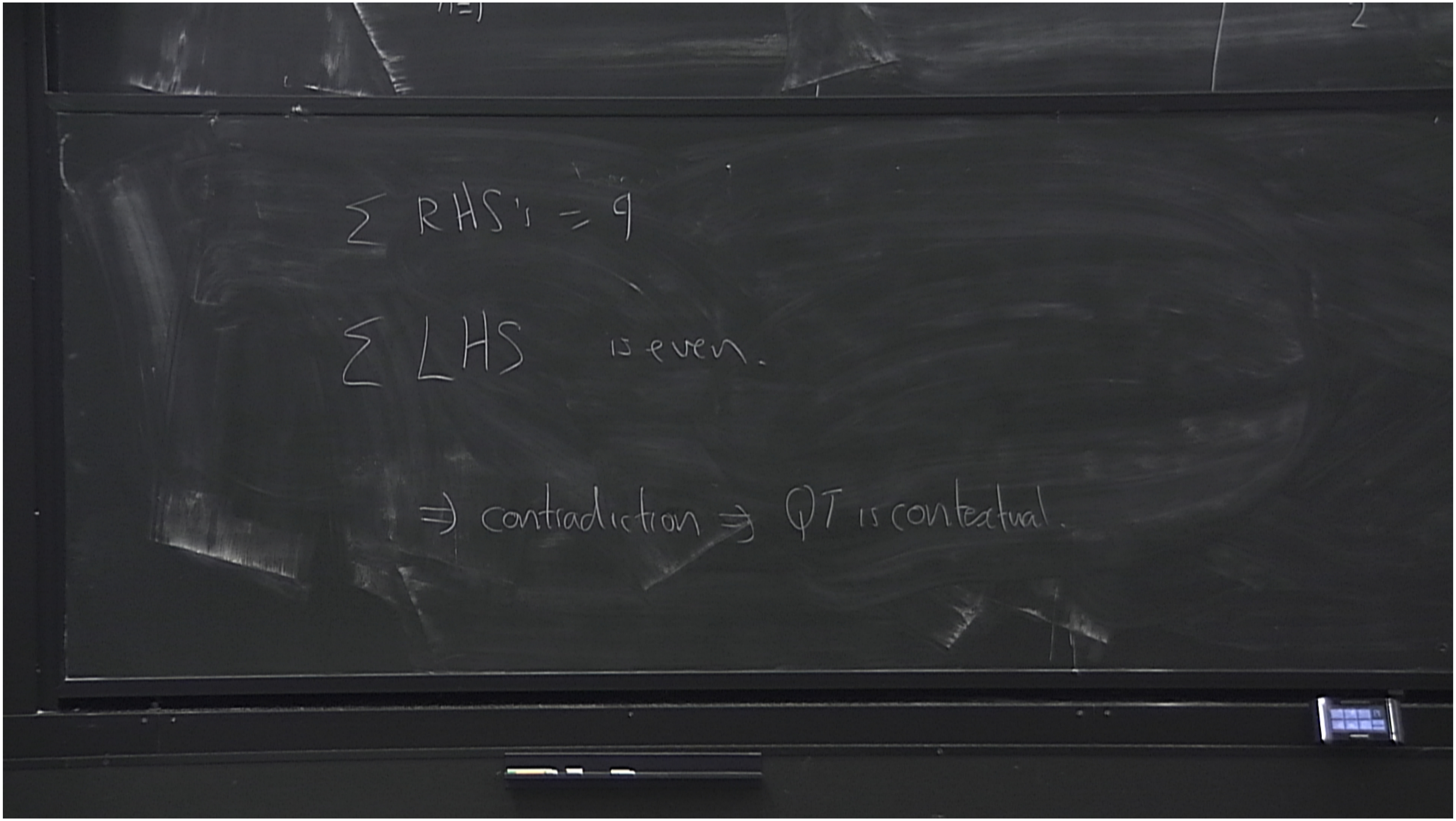
2. $v(0,0,0,1) + v(0,1,0,0) + v(1,0,1,0) + v(1,0,-1,0) = 1$

9.

$\sum$ RHS's $= 9$

$\sum$ LHS is even.

$\Rightarrow$ contradiction $\Rightarrow$ QT is contextual.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