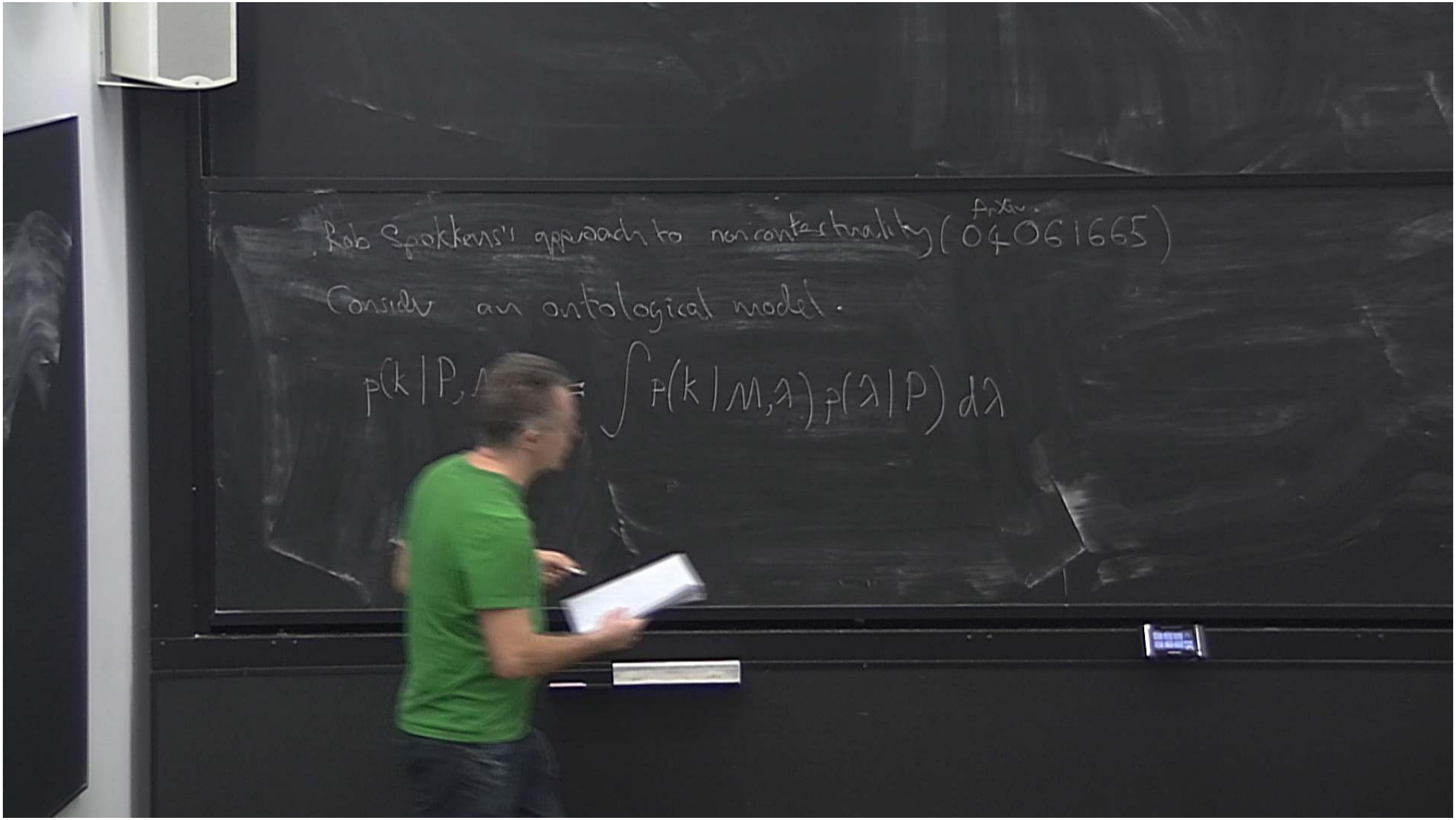
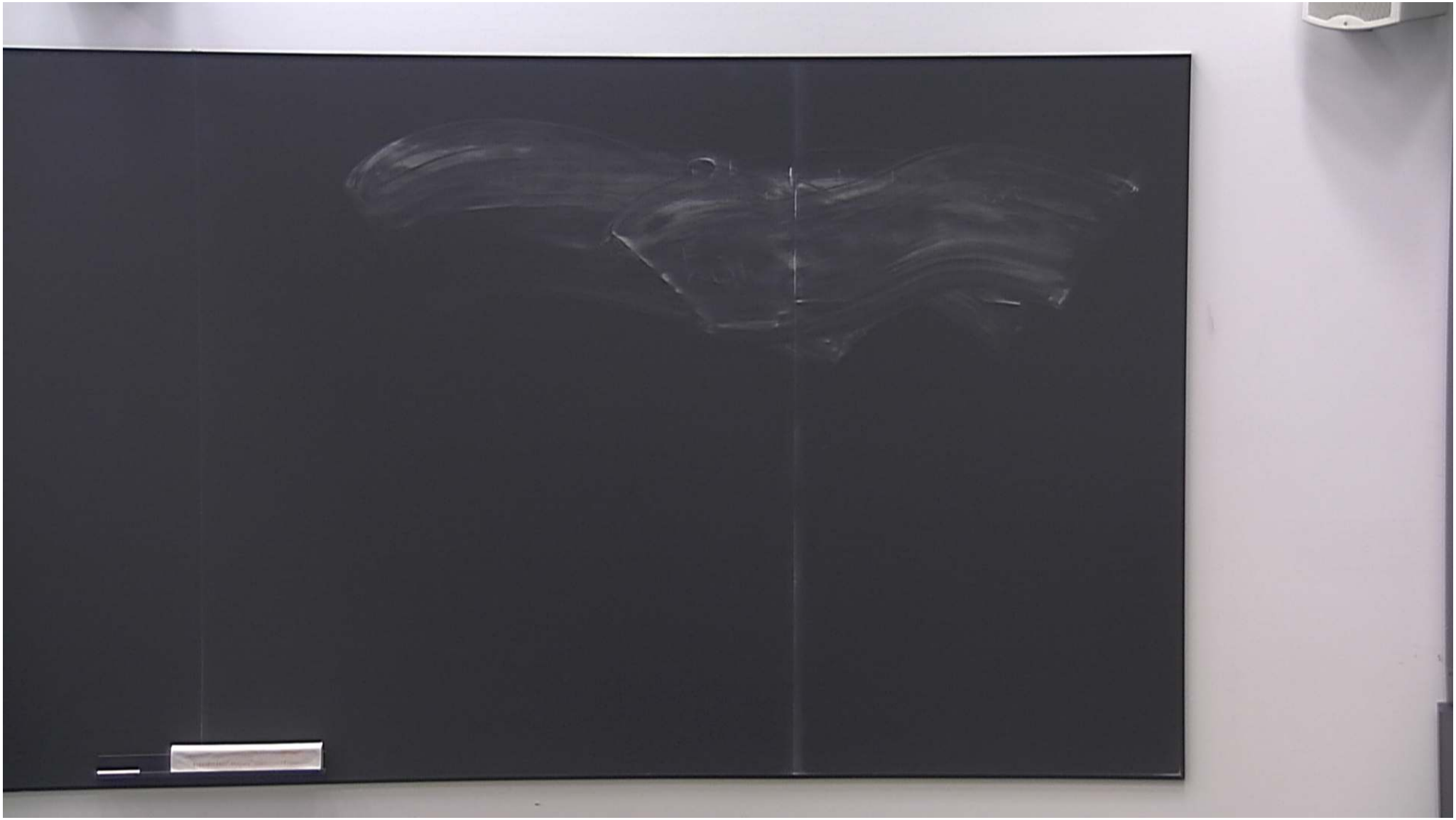
Title: 13/14 PSI - Foundations of Quantum Mechanics - Lecture 12

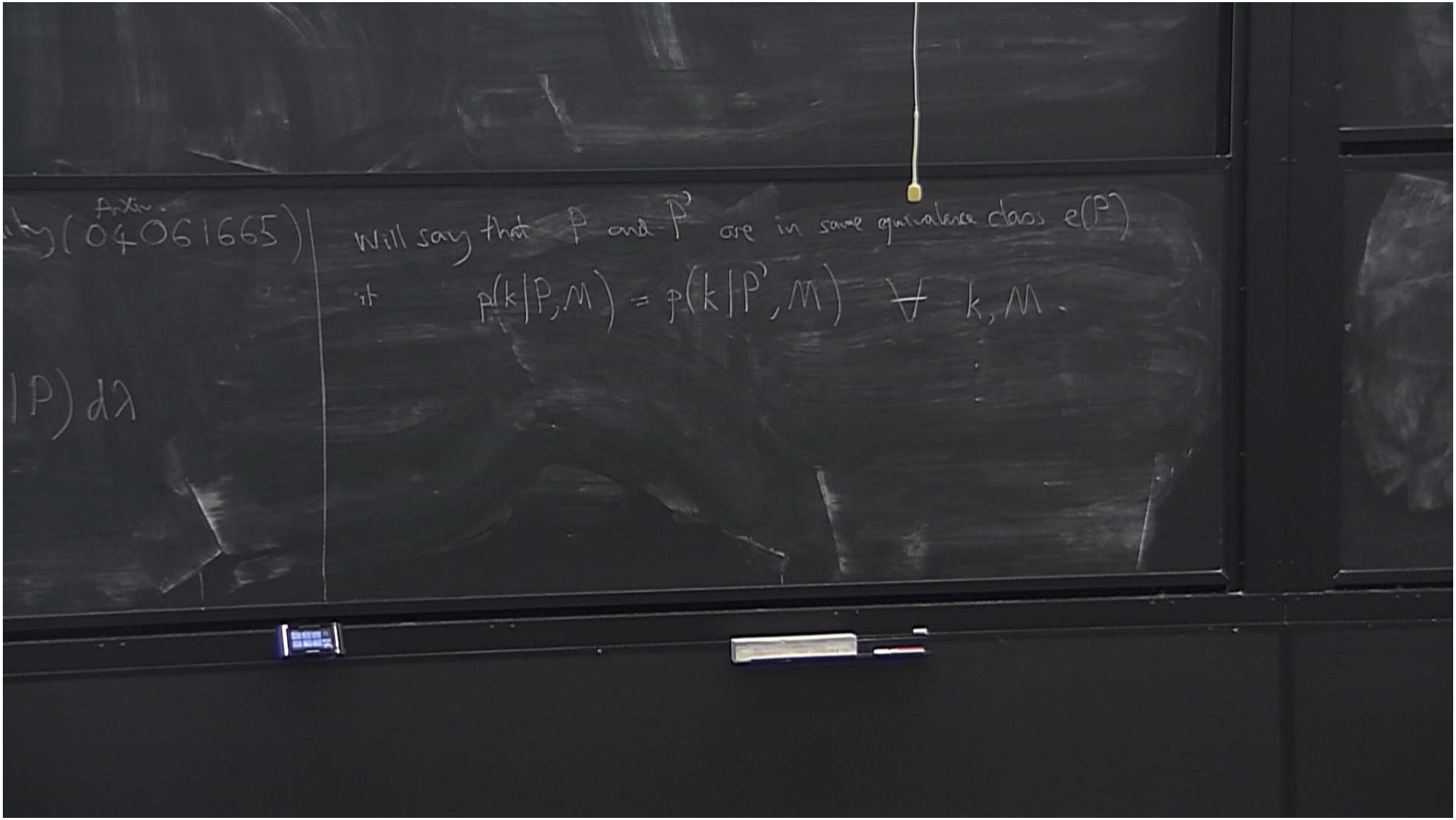
Date: Jan 21, 2014 11:30 AM

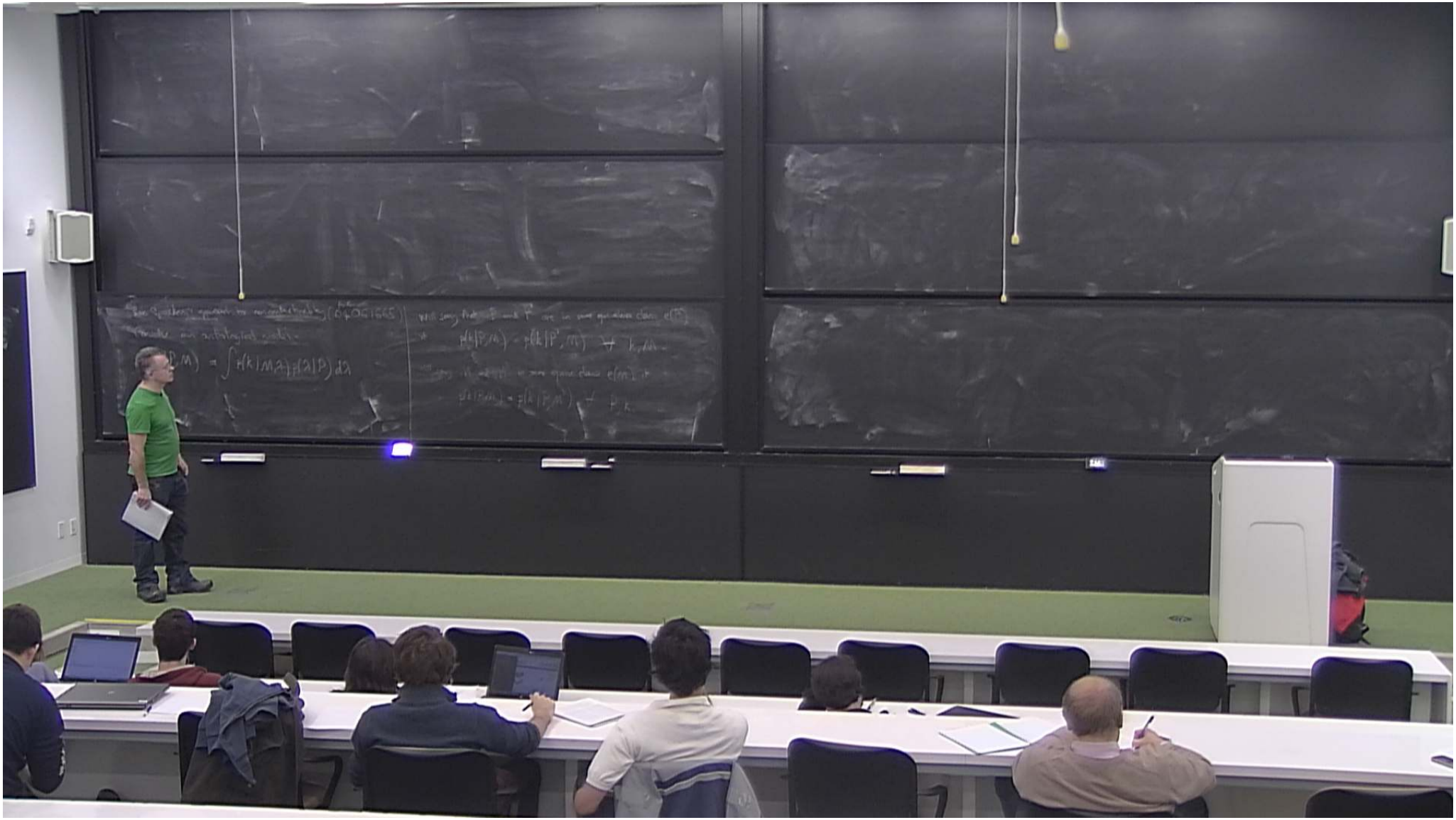
URL: http://pirsa.org/14010061

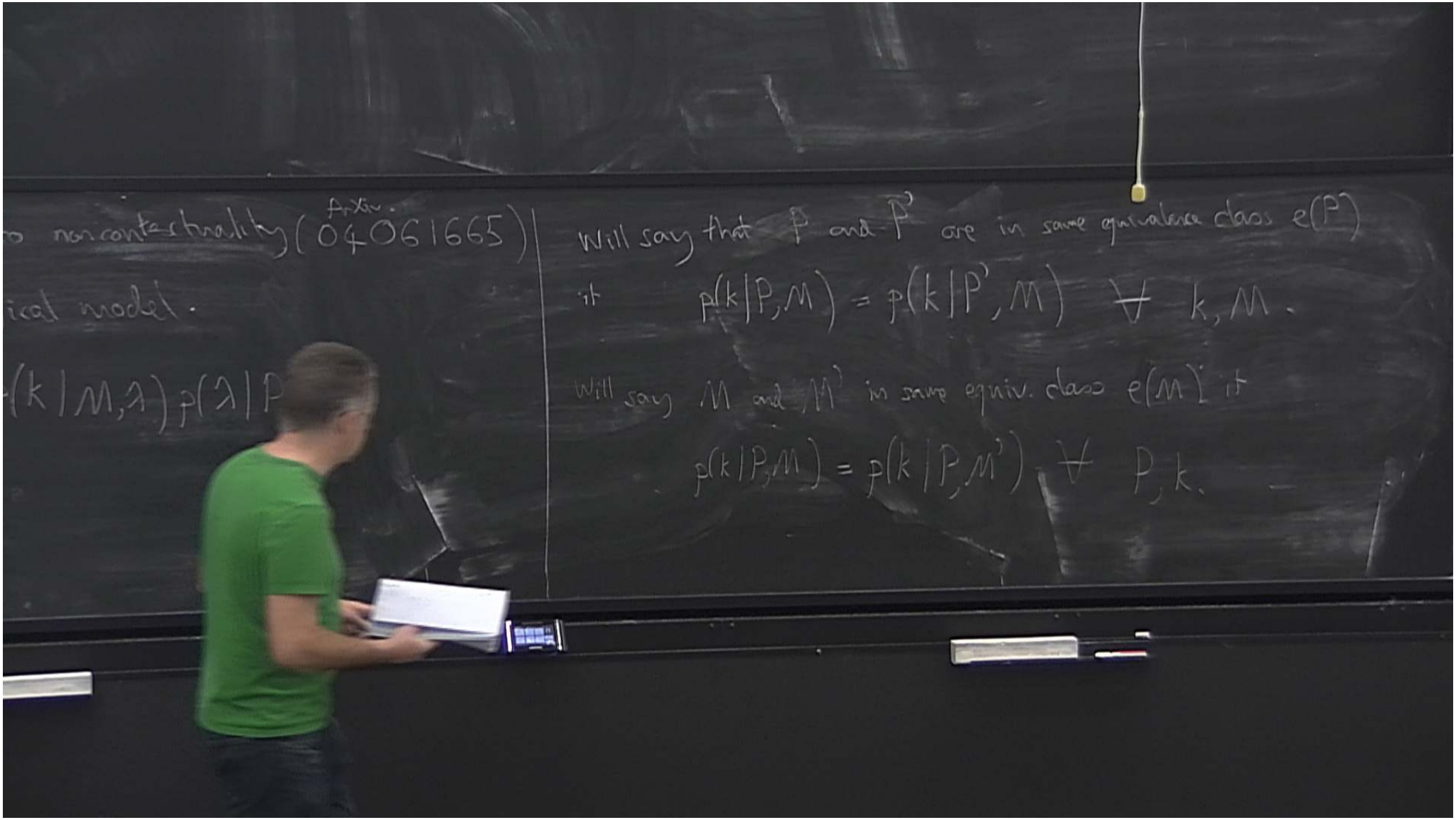
Abstract:


Rob Spekkens's approach to noncontextuality (Arxiv. 0406 1665)
Consider an ontological model.
$p(k|P,\Lambda = \int p(k|M,\lambda)\, p(\lambda|P)\, d\lambda$

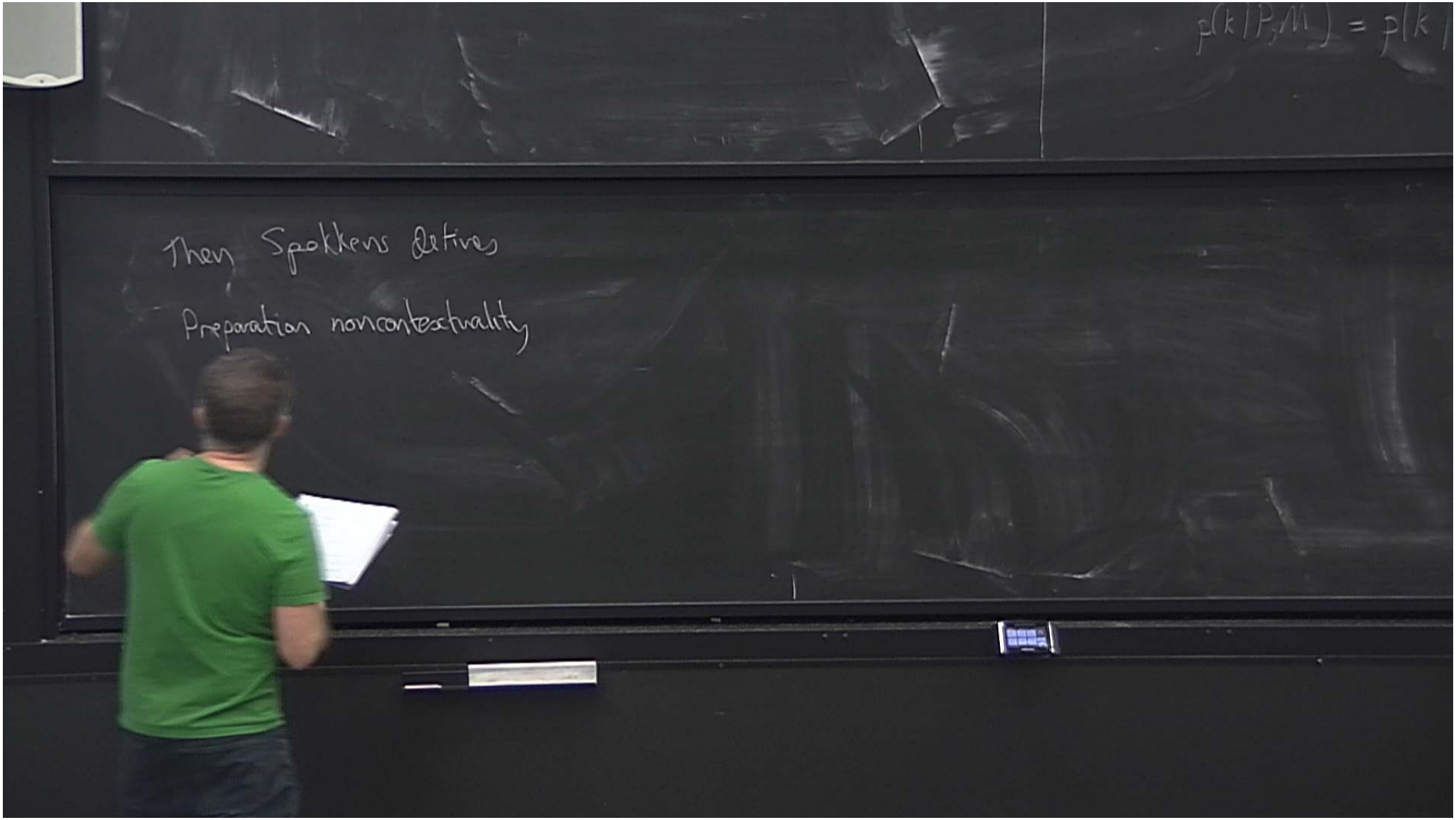


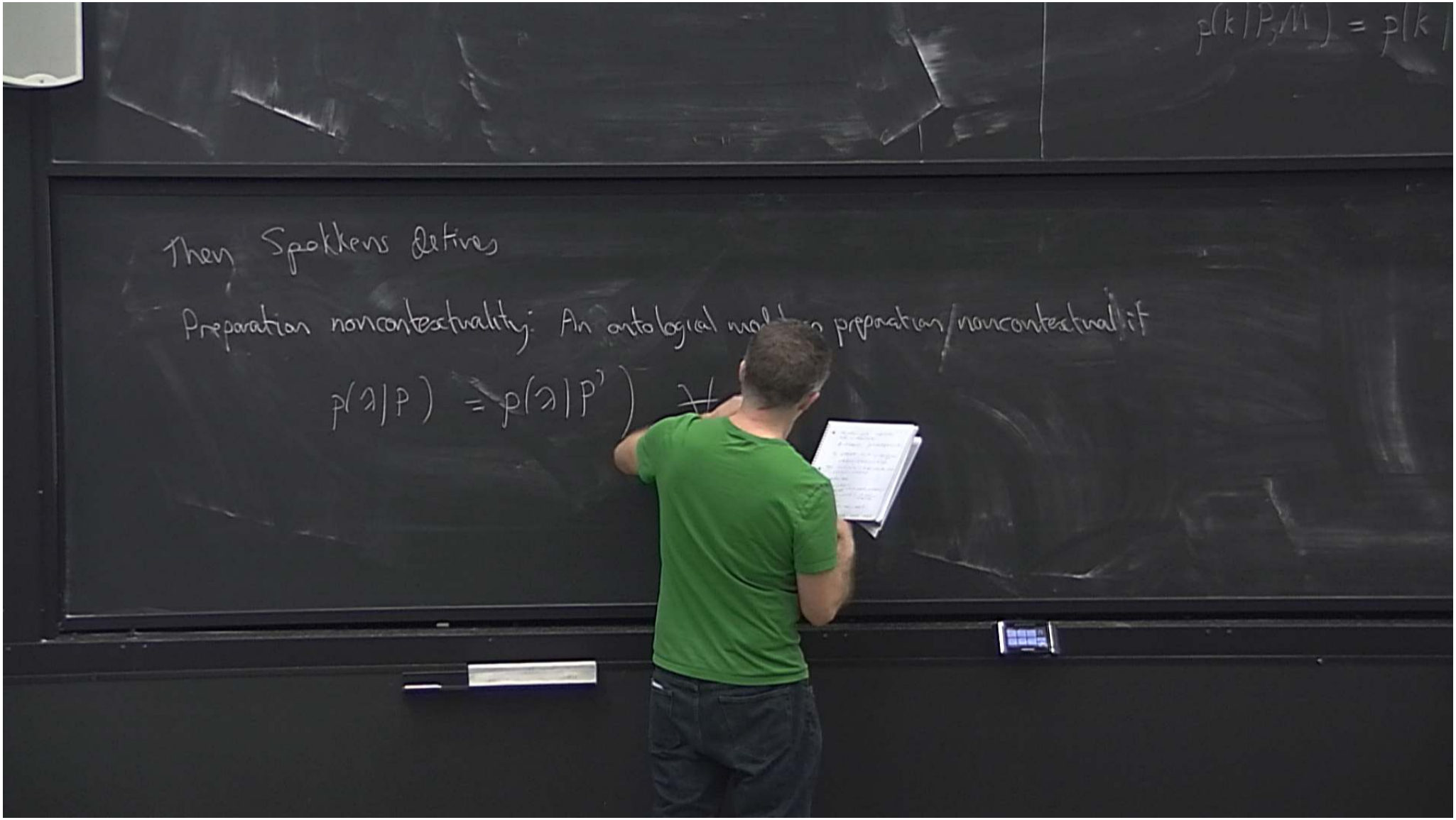

(Axiv. 0406 1665)
Will say that P and P' are in same equivalence class e(P)
if p(k|P,M) = p(k|P',M) ∀ k, M.
P) dλ





o noncontextuality (Arxiv. 04061665)
ical model.
(k | M, λ) p(λ | P
Will say that P and P' are in same equivalence class e(P)
if p(k|P,M) = p(k|P',M) ∀ k, M.
Will say M and M' in same equiv. class e(M) if
p(k|P,M) = p(k|P,M') ∀ P, k.


Then Spekkens def ines
Preparation noncontextuality


Then Spekkens defines
Preparation noncontextuality: An ontological
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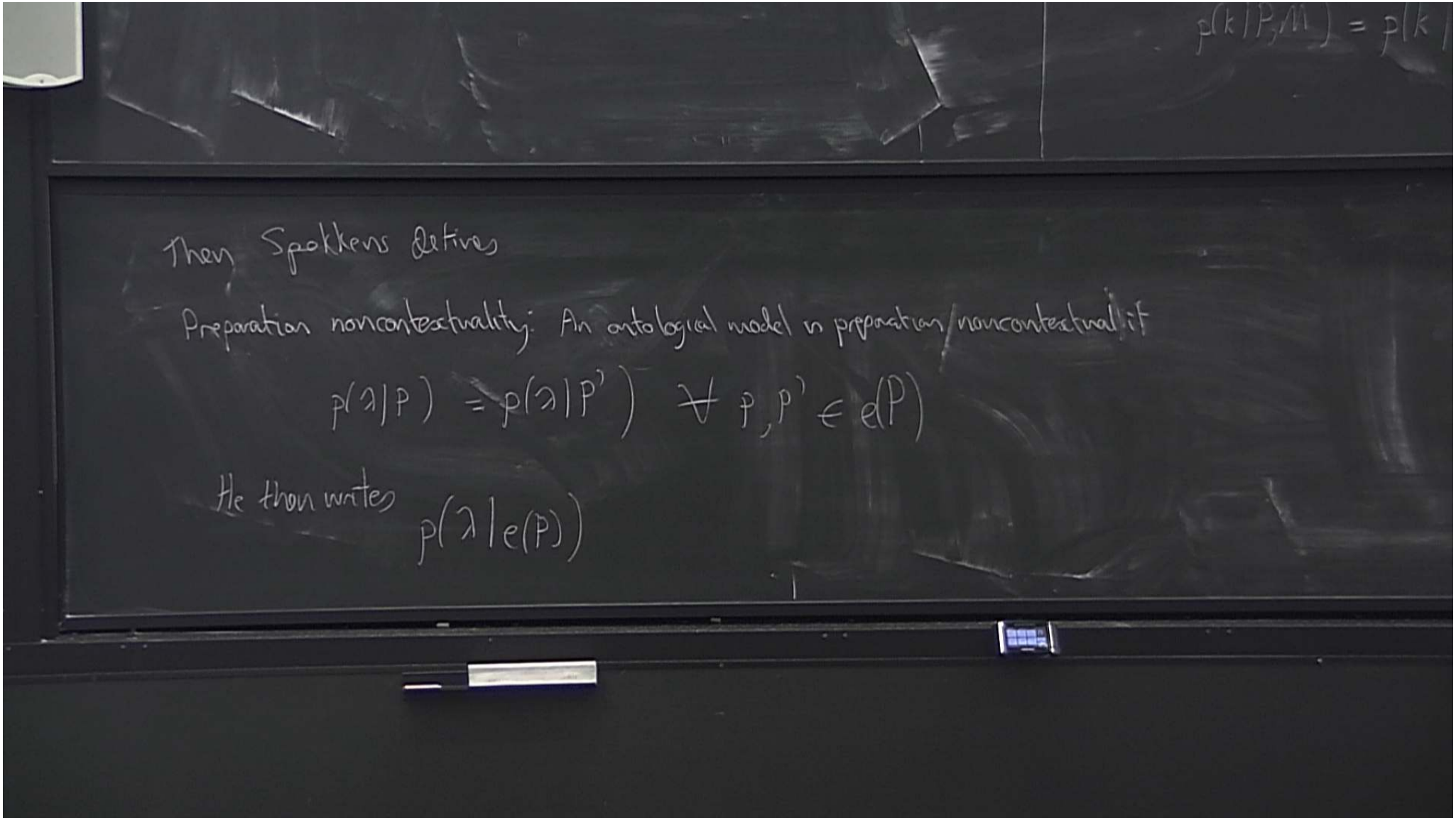
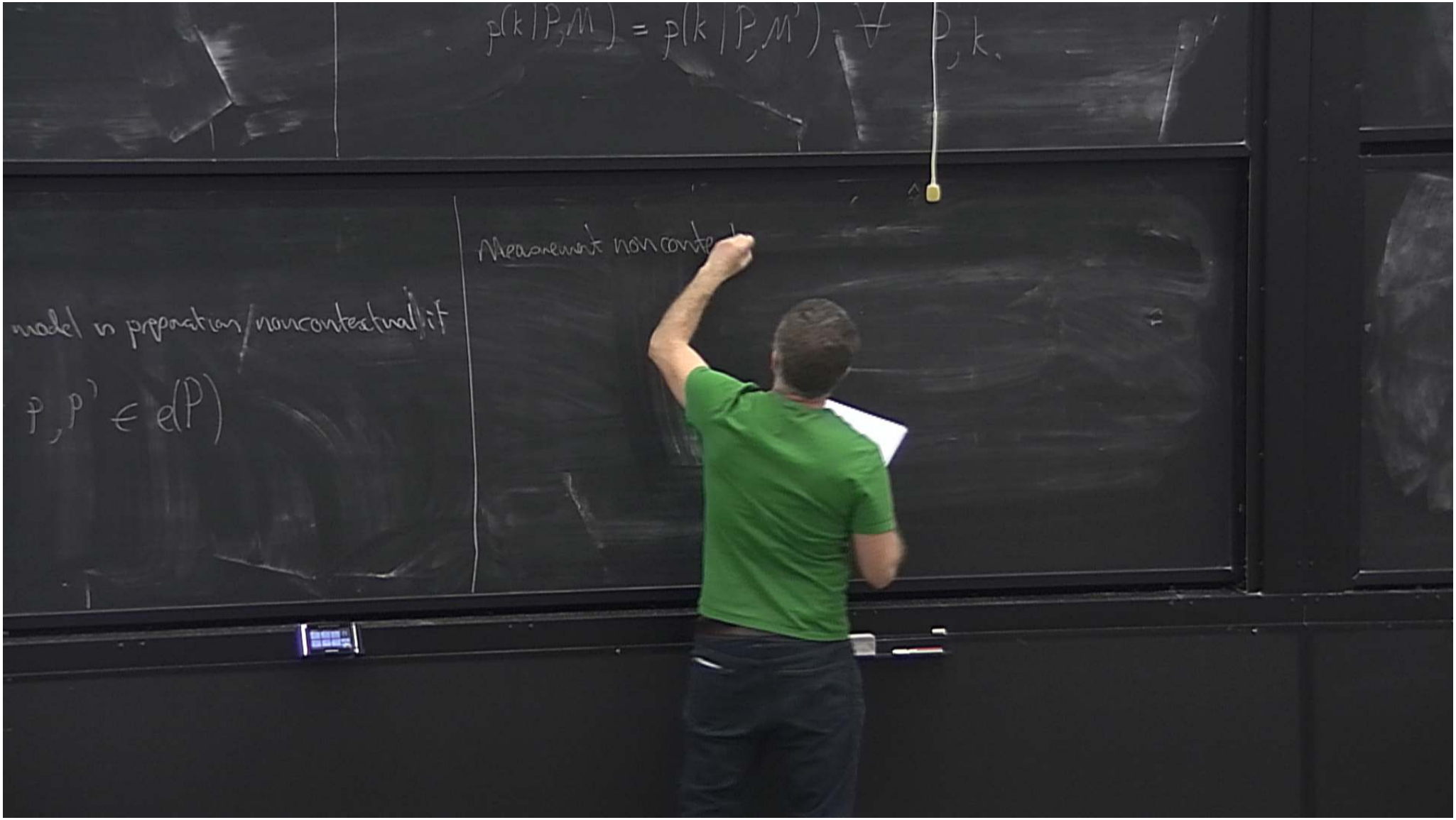
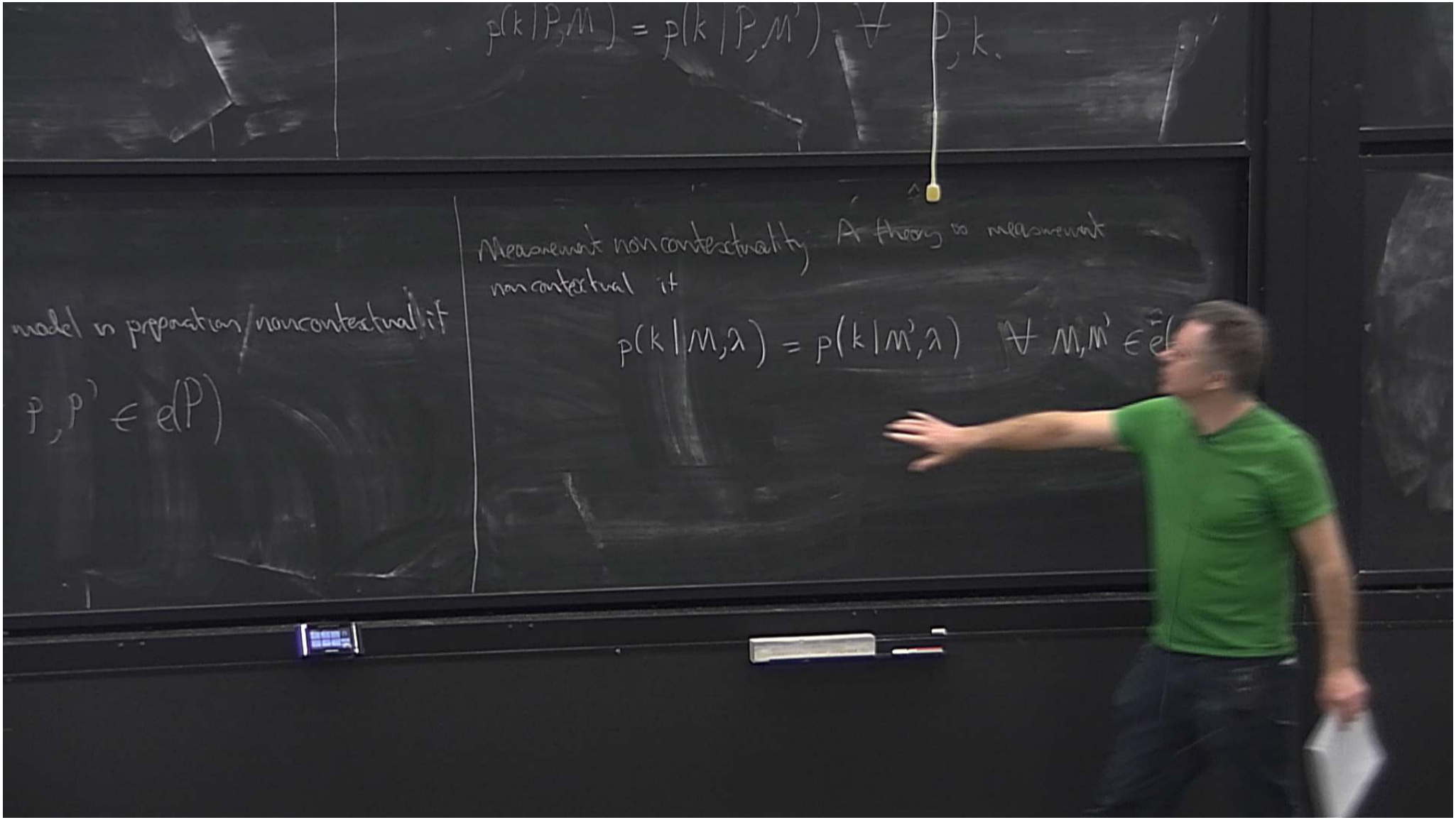
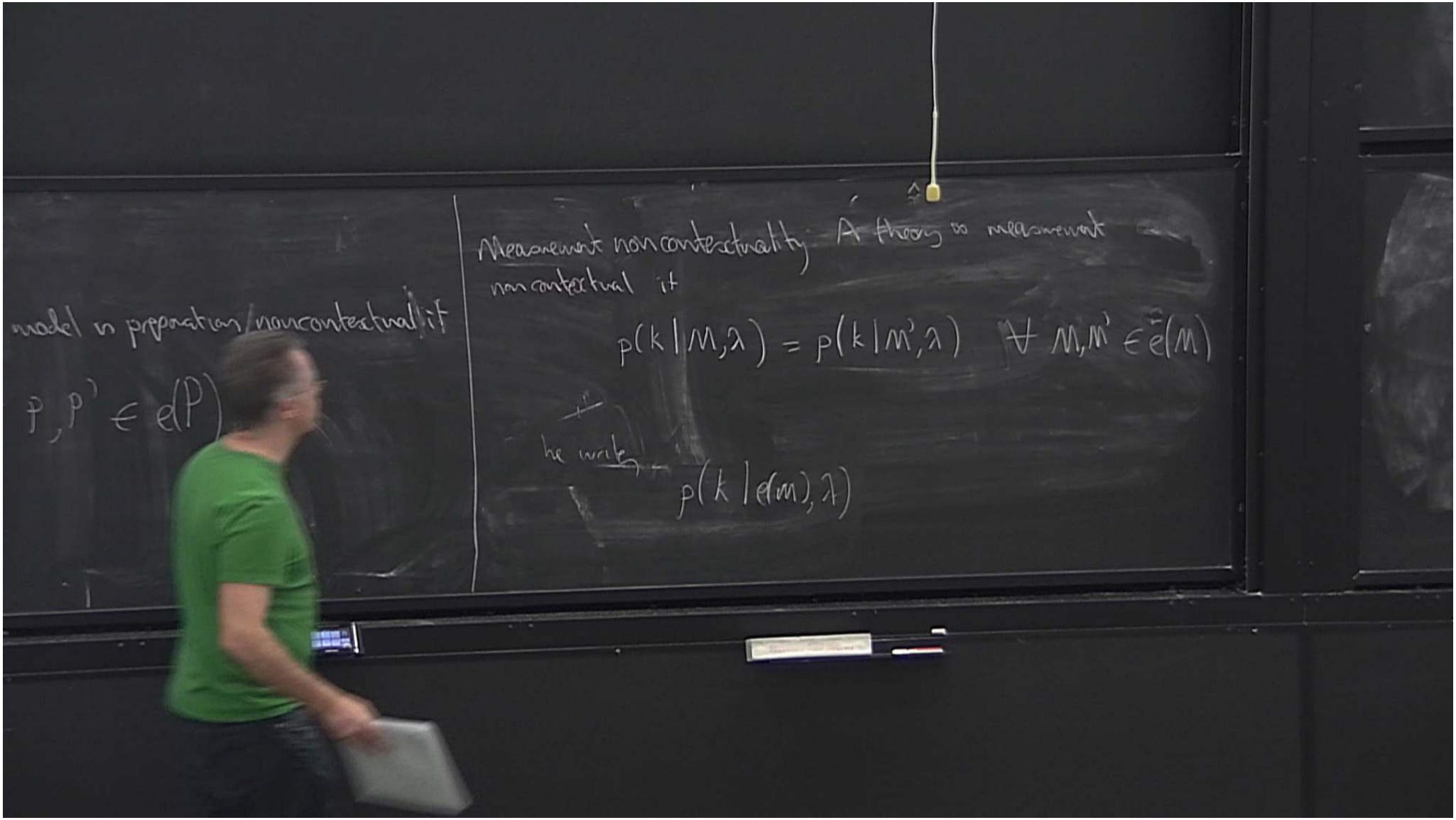
$p(\lambda|P) = p(\lambda|P')$


$p(k|P,M) = p(k|$
Then Spekkens defines
Preparation noncontextuality: An ontological model is preparation noncontextual if
$p(\lambda|P) = p(\lambda|P') \quad \forall P, P' \in e(P)$
He then writes
$p(\lambda|e(P))$


p(k|P,M) = p(k|P,M') ∀ P, k.
Measurement noncont
model is preparation noncontextual if
P, P' ∈ e(P)


$p(k|P,M) = p(k|P,M') \quad \forall \; P, k.$
model is preparation noncontextual if
$P, P' \in e(P)$
Measurement noncontextuality. A theory is measurement noncontextual if
$p(k|M,\lambda) = p(k|M',\lambda) \quad \forall \; M, M' \in \tilde{e}($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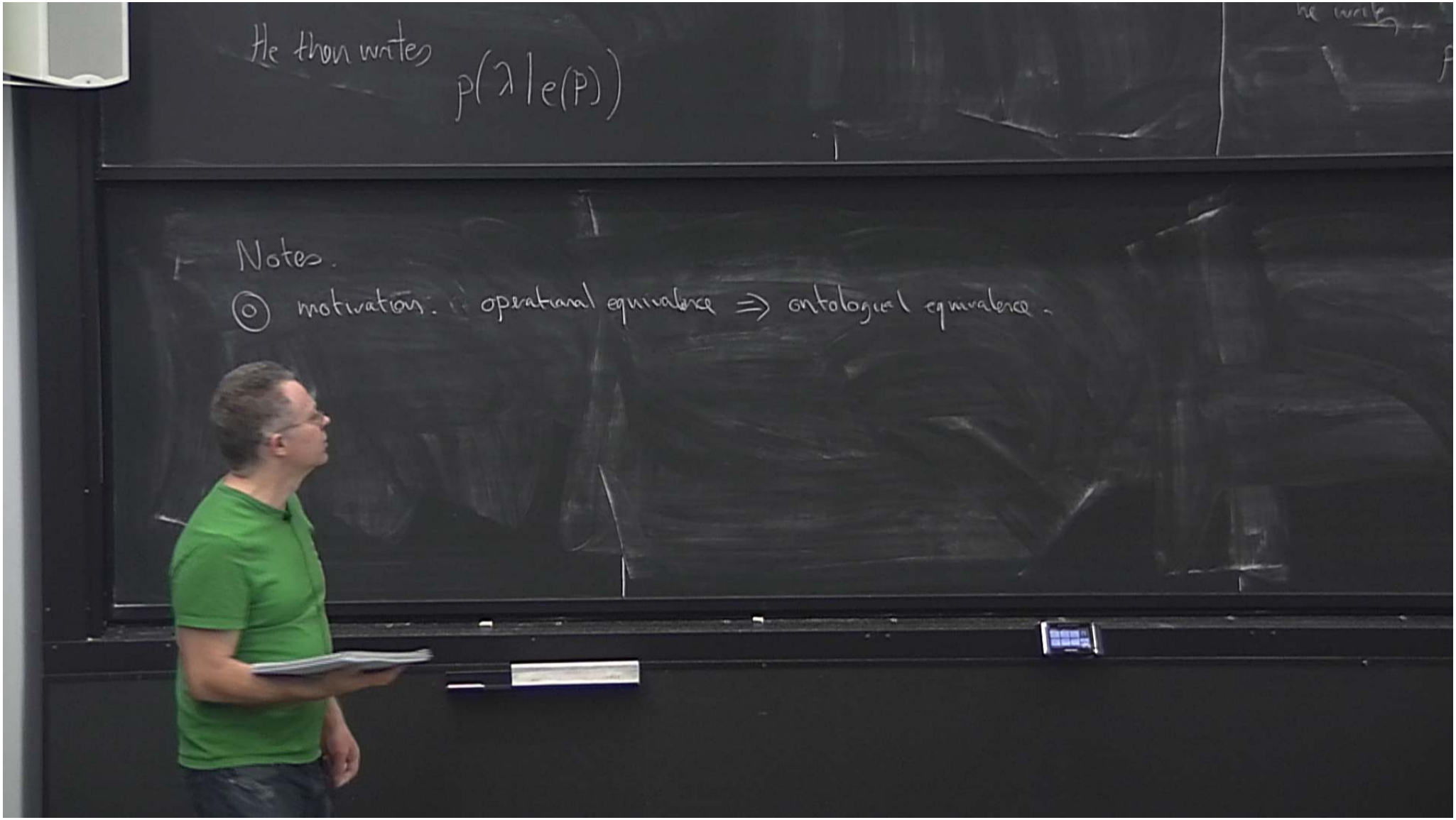
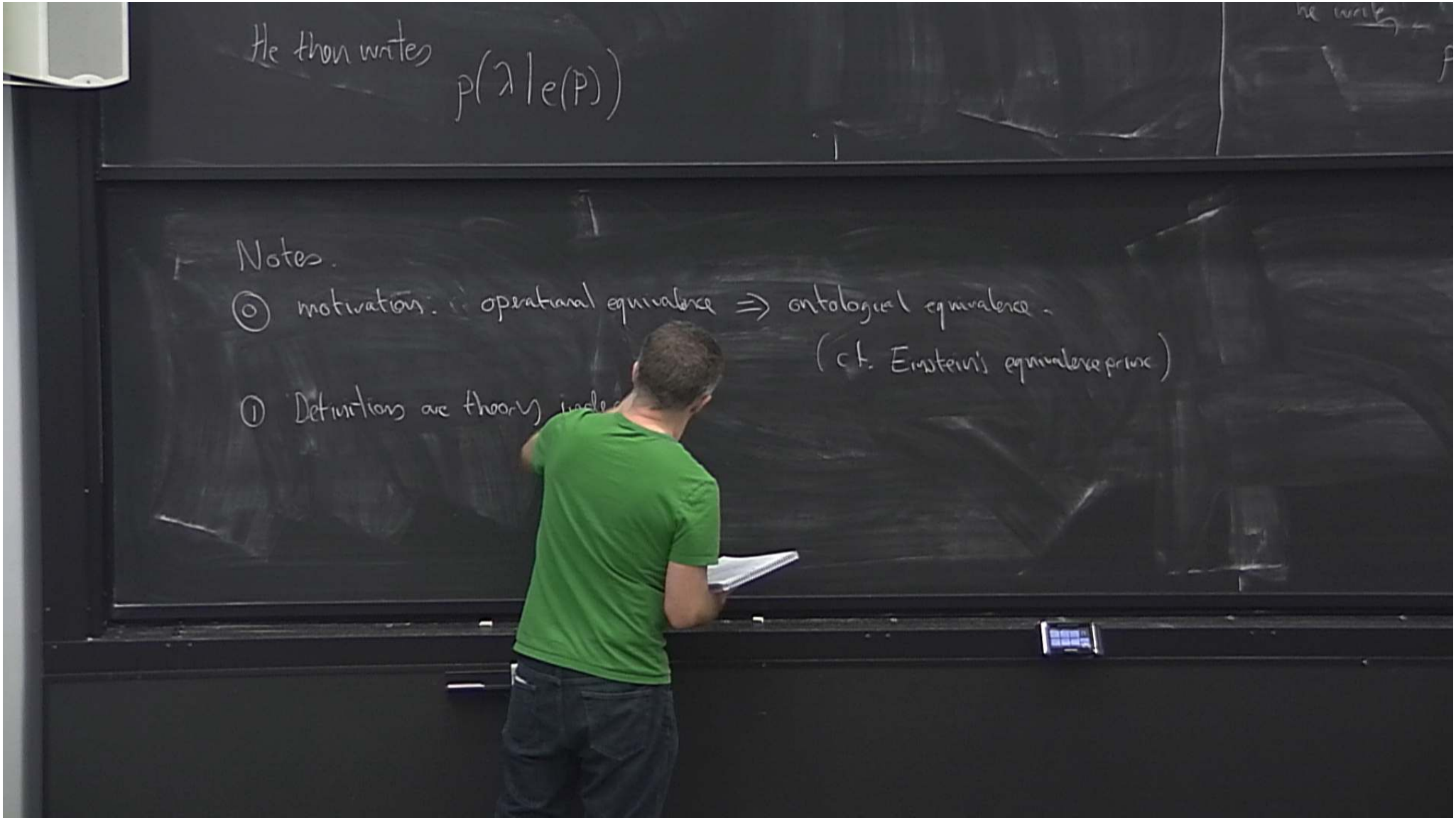
Measurement noncontextuality: A theory is measurement noncontextual if
$p(k|M,\lambda) = p(k|M',\lambda) \quad \forall M, M' \in e(M)$
he writes
$p(k|e(M),\lambda)$


He then writes
$p(\lambda|e(P))$
Notes.
motivation: operational equivalence $\Rightarrow$ ontological equivalence.


He then writes
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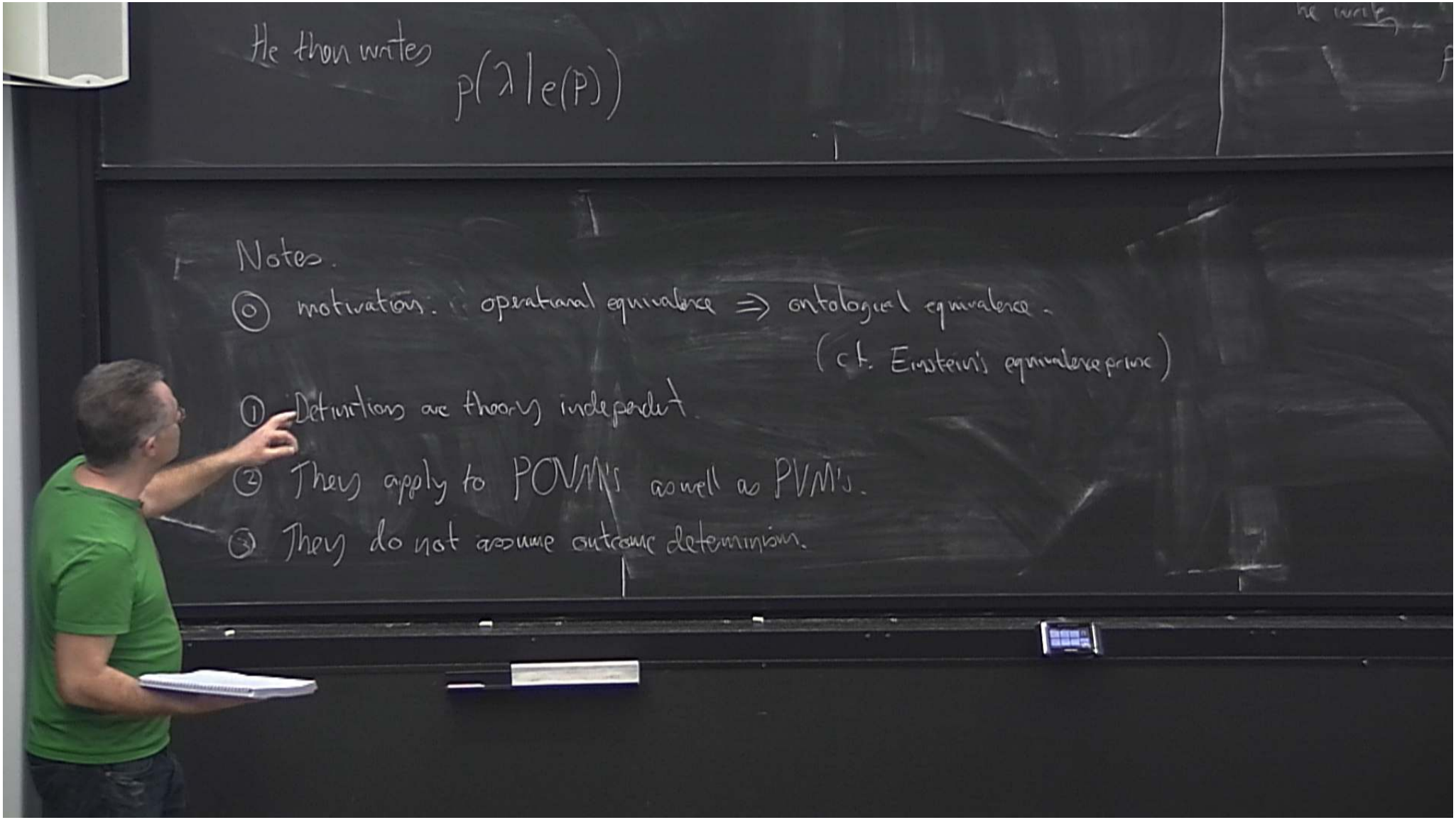
Notes.
① motivation: operational equivalence ⇒ ontological equivalence.
(cf. Einstein's equivalence princ)
① Definitions are theory


He then writes $p(\lambda|e(P))$
Notes.
① motivation: operational equivalence ⇒ ontological equivalence.
(cf. Einstein's equivalence princ)
① Definitions are theory independent
② They apply to POVM's as well as PVM's.
③ They do not assume outcome determinism.

He then writes $p(\lambda | e(P))$

Notes.

(0) motivation: operational equivalence $\Rightarrow$ ontological equivalence.

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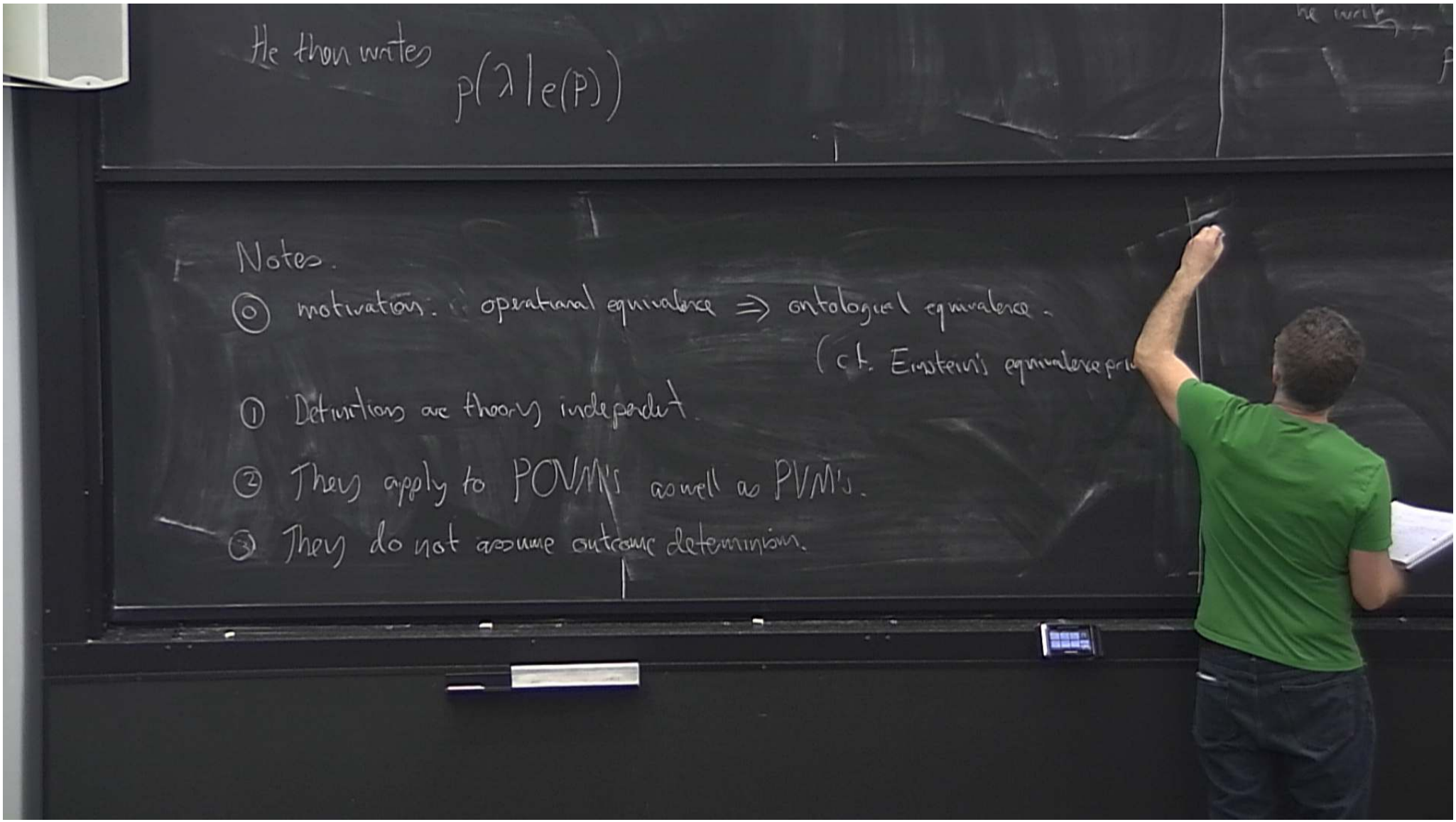
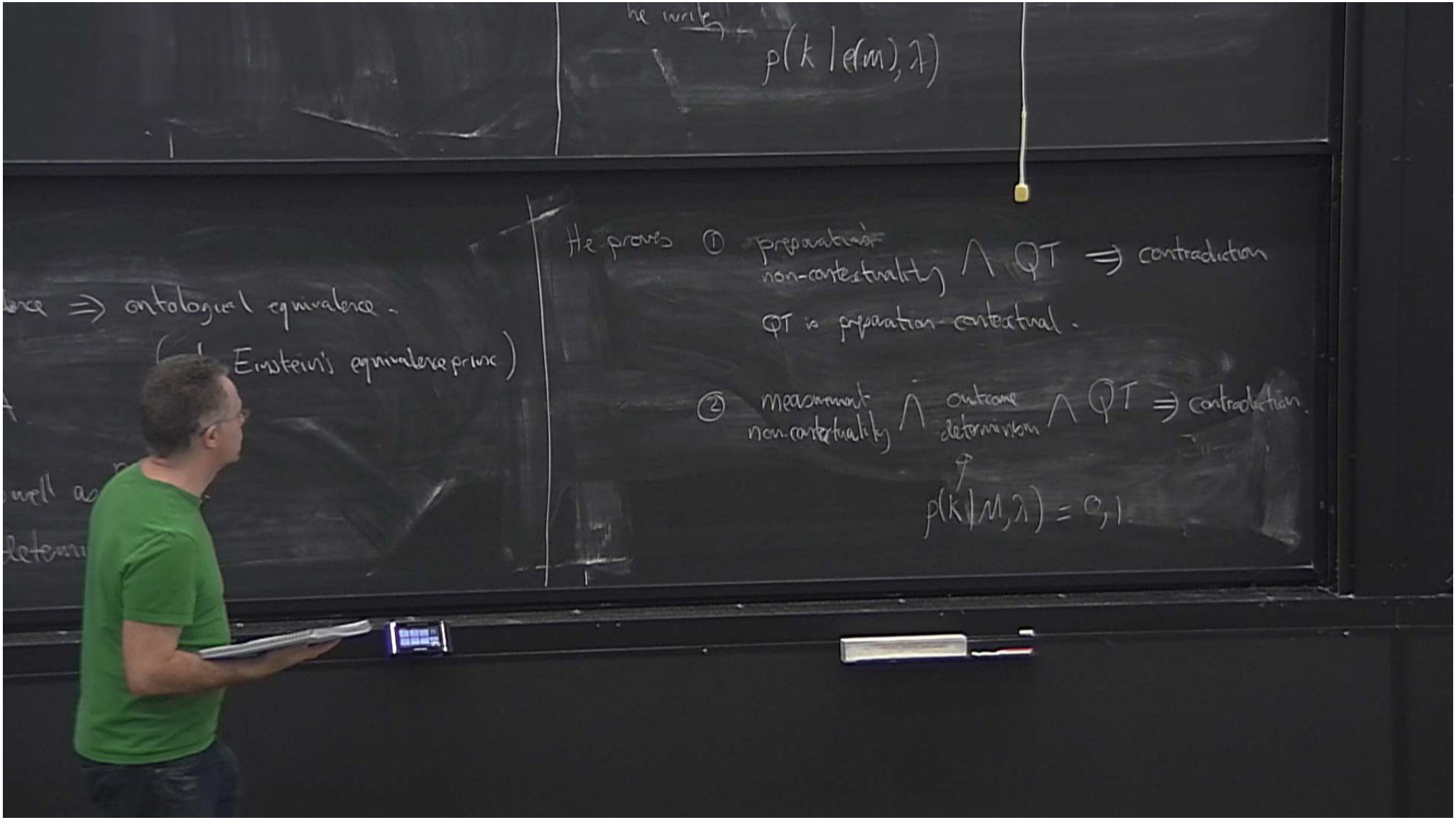
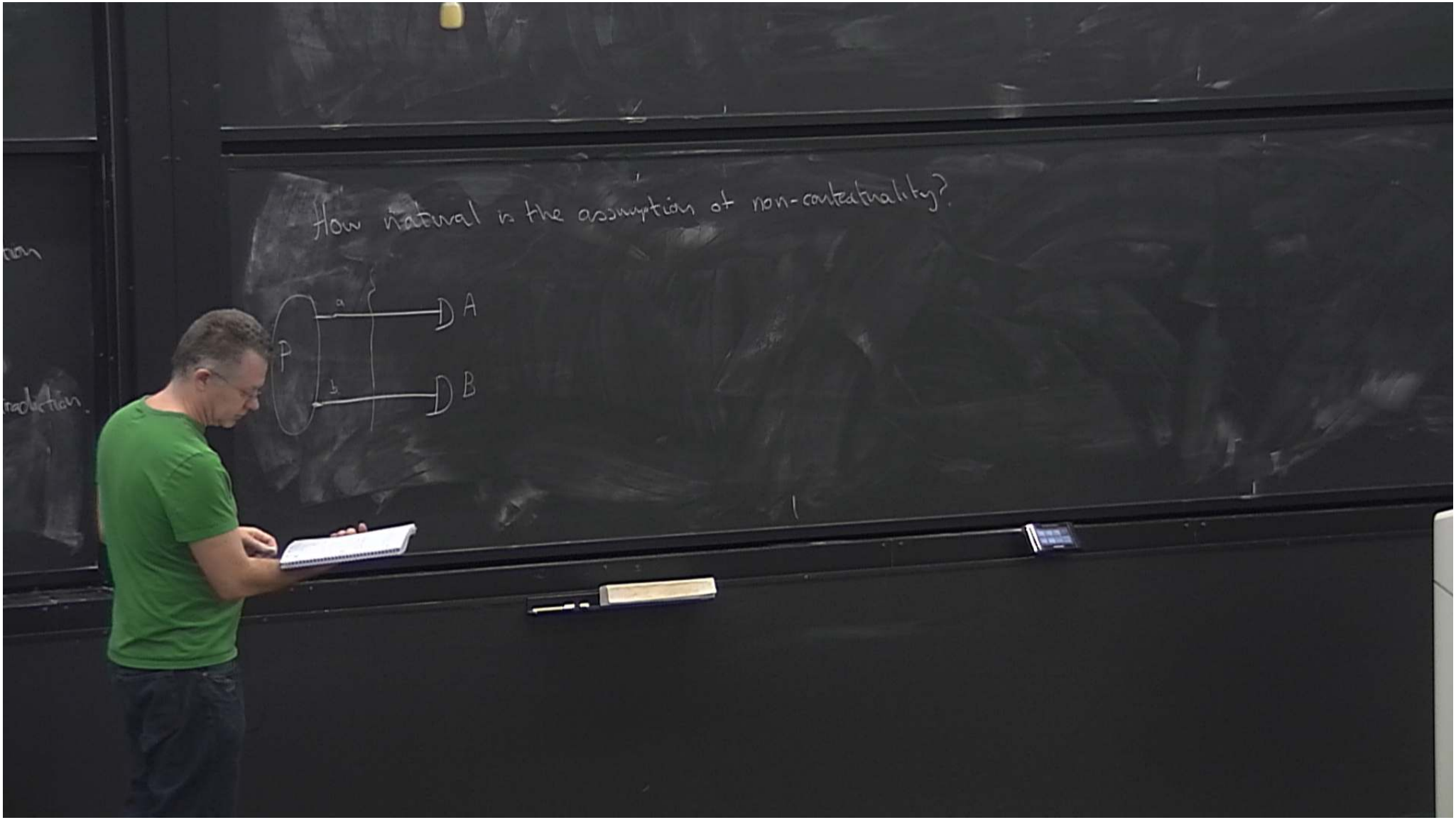
(1) Definitions are theory independent.

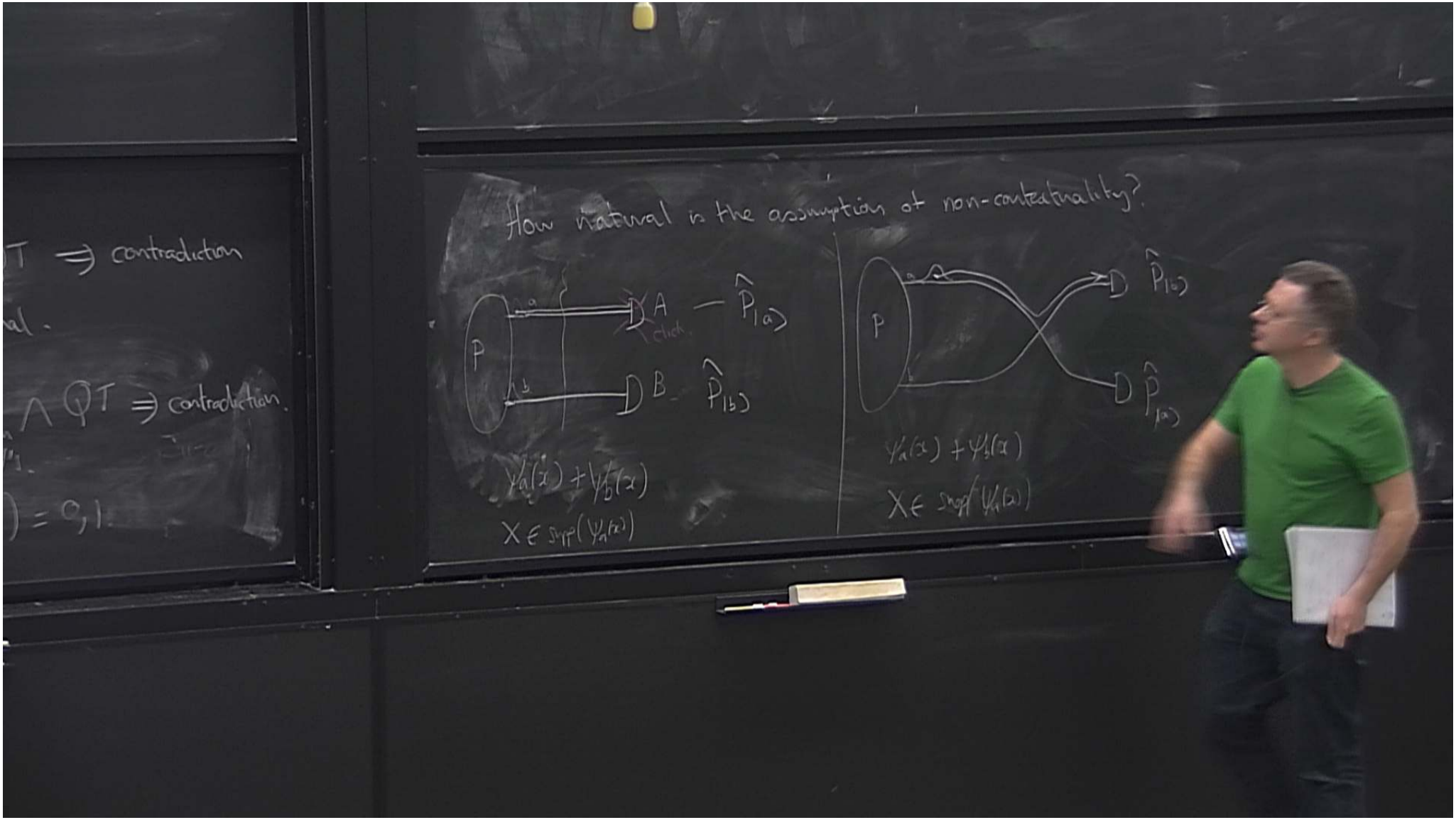
(2) They apply to POVM's as well as PVM's.

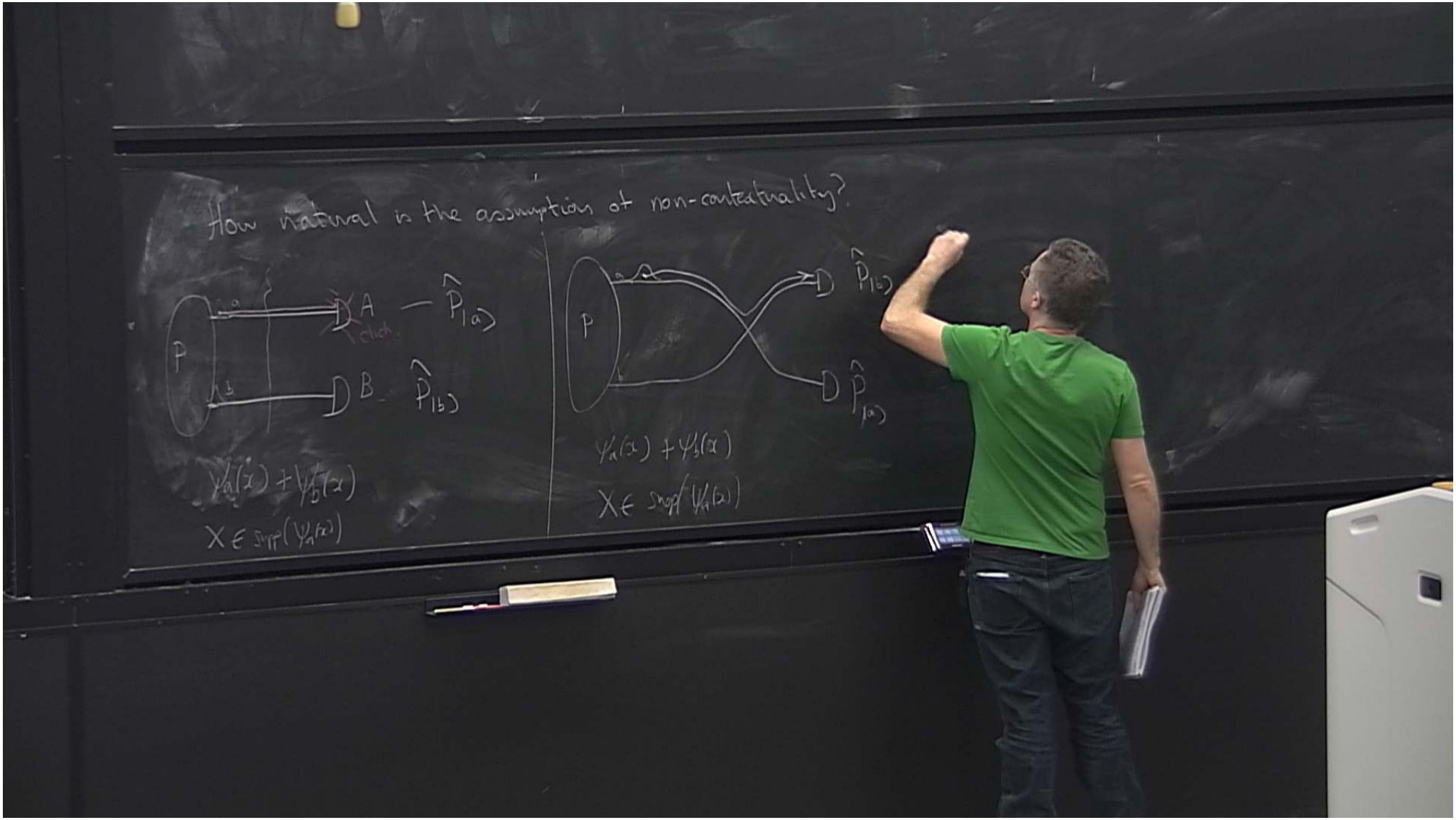
(3) They do not assume outcome determinism.




he writes
$p(k|e(m),\lambda)$
He proves ① preparation non-contextuality $\wedge$ QT $\Rightarrow$ contradiction
QT is preparation-contextual.
② measurement non-contextuality $\wedge$ outcome determinism $\wedge$ QT $\Rightarrow$ contradiction.
$p(k|M,\lambda) = 0,1$
$\Rightarrow$ ontological equivalence.
(Einstein's equivalence principle)


How natural is the assumption of non-contextuality?
P
a
A
b
B


How natural is the assumption of non-contextuality?
P
A
B
click
$\hat{P}_{|a\rangle}$
$\hat{P}_{|b\rangle}$
$\psi_a(x) + \psi_b(x)$
$X \in \mathrm{Supp}(\psi_a(x))$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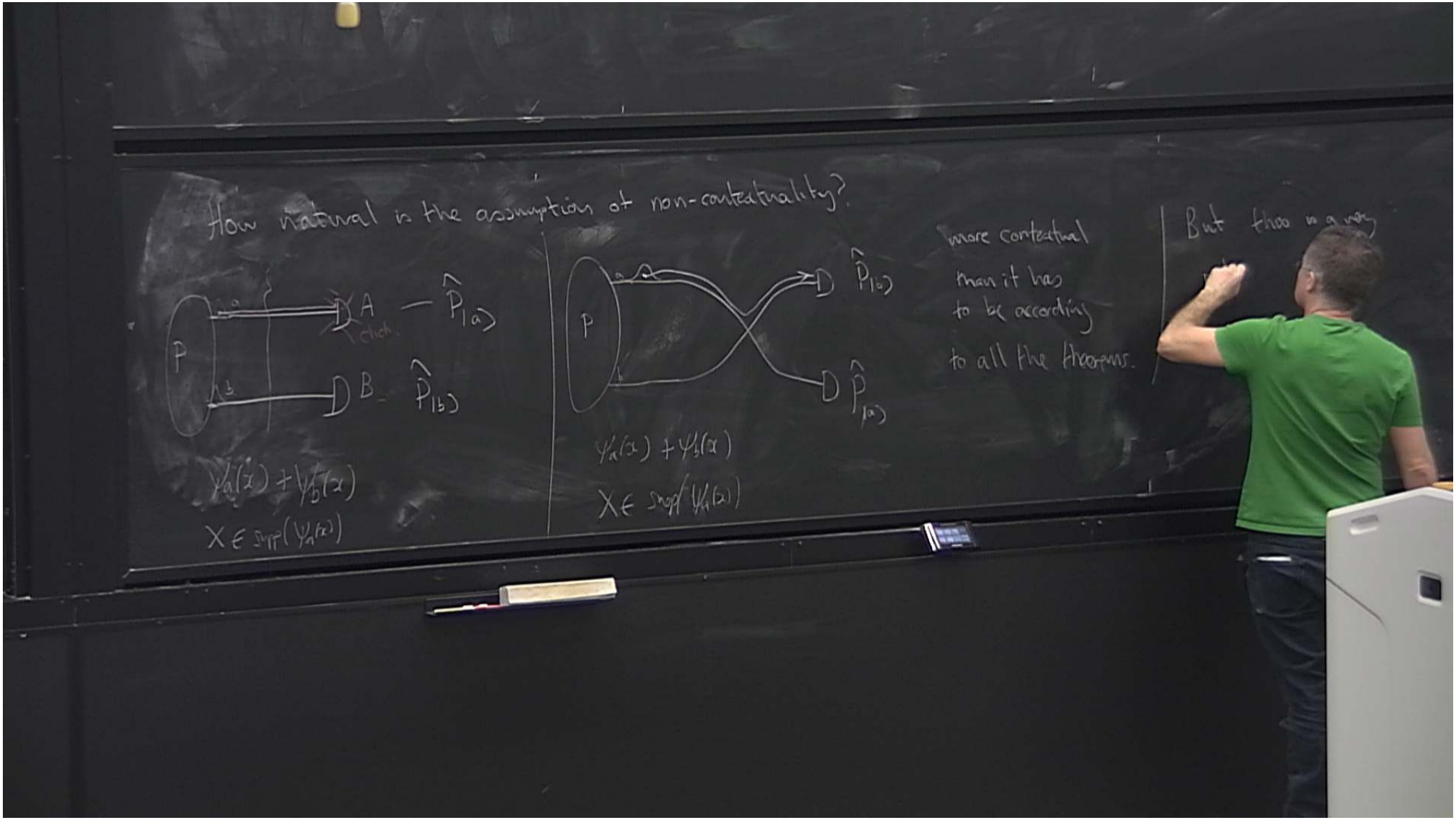
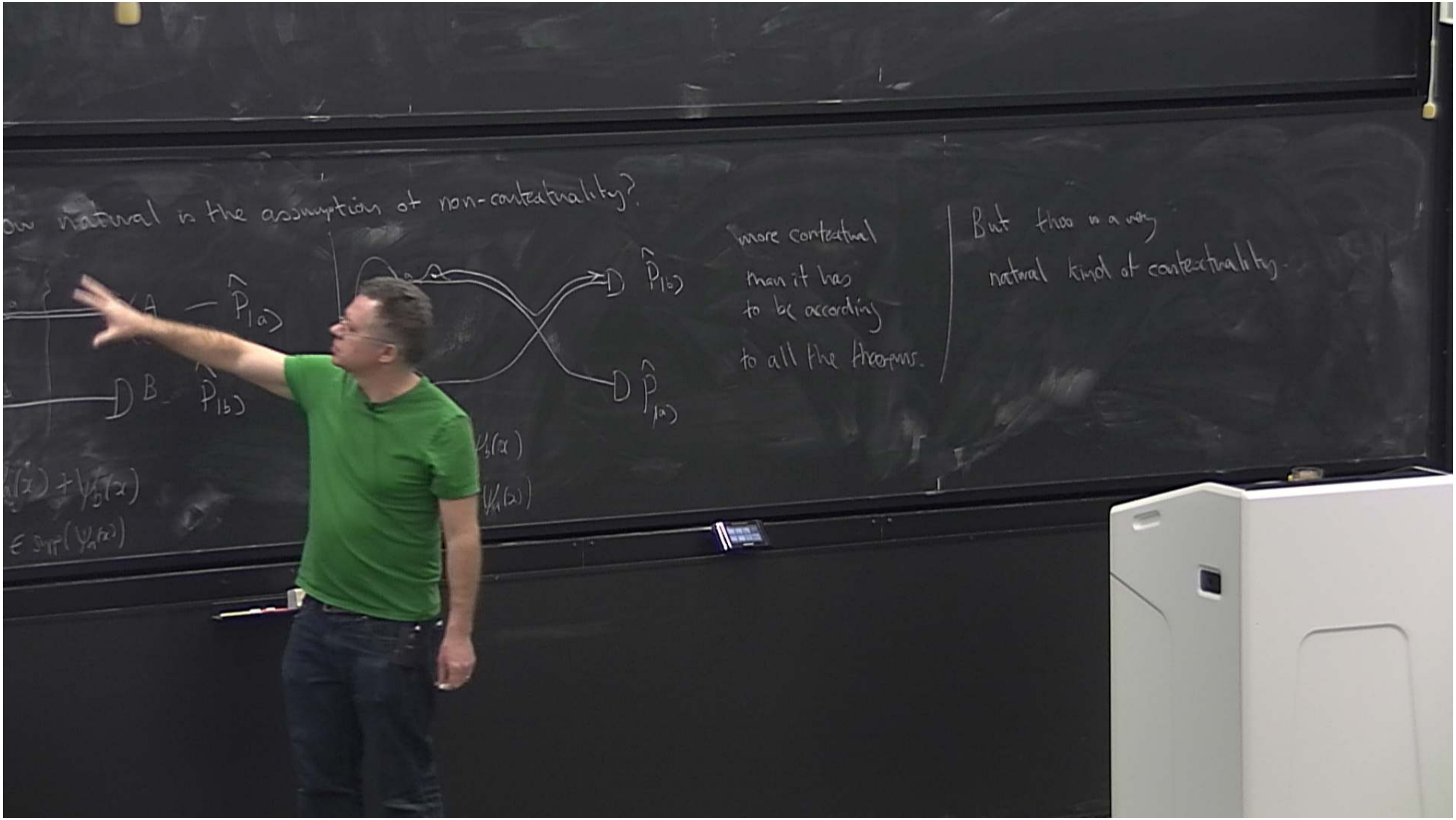

How natural is the assumption of non-contextuality?
P
A
click
B
more contextual
than it has
to be according
to all the theorems.
But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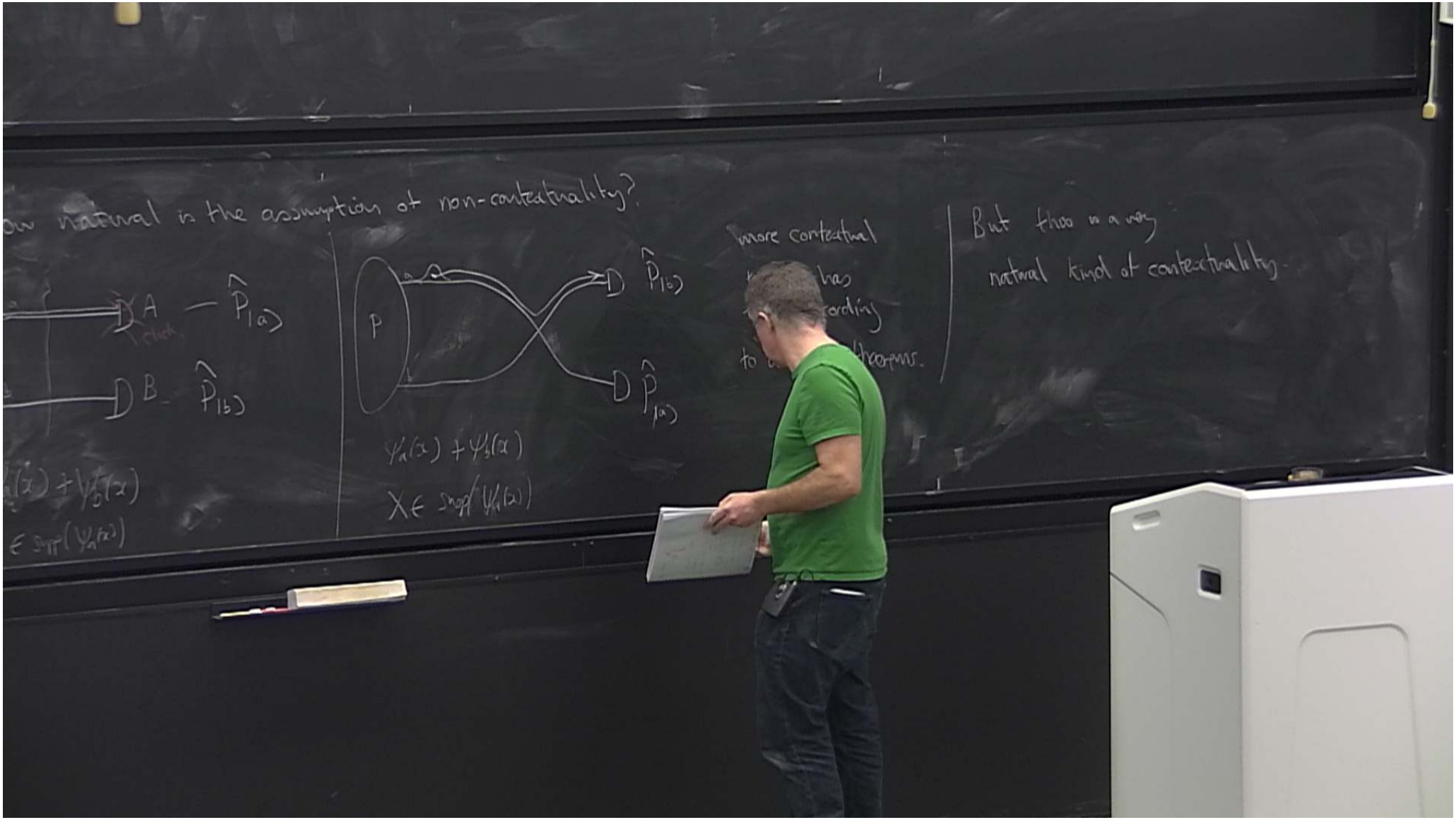
more contextual
than it has
to be according
to all the theorems.
But there is a very
natural kind of contextuality.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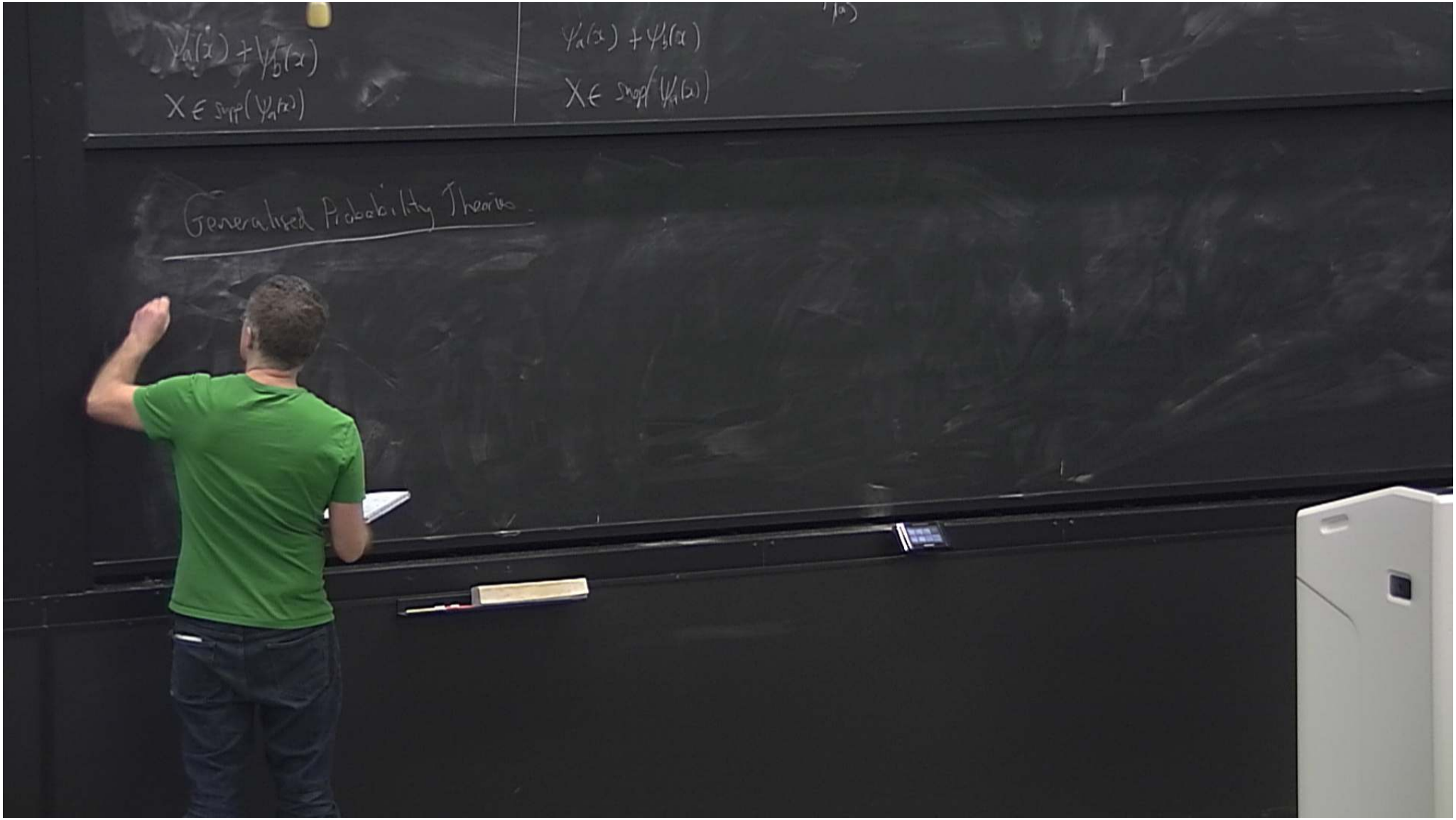
$\psi_a(x) + \psi_b(x)$
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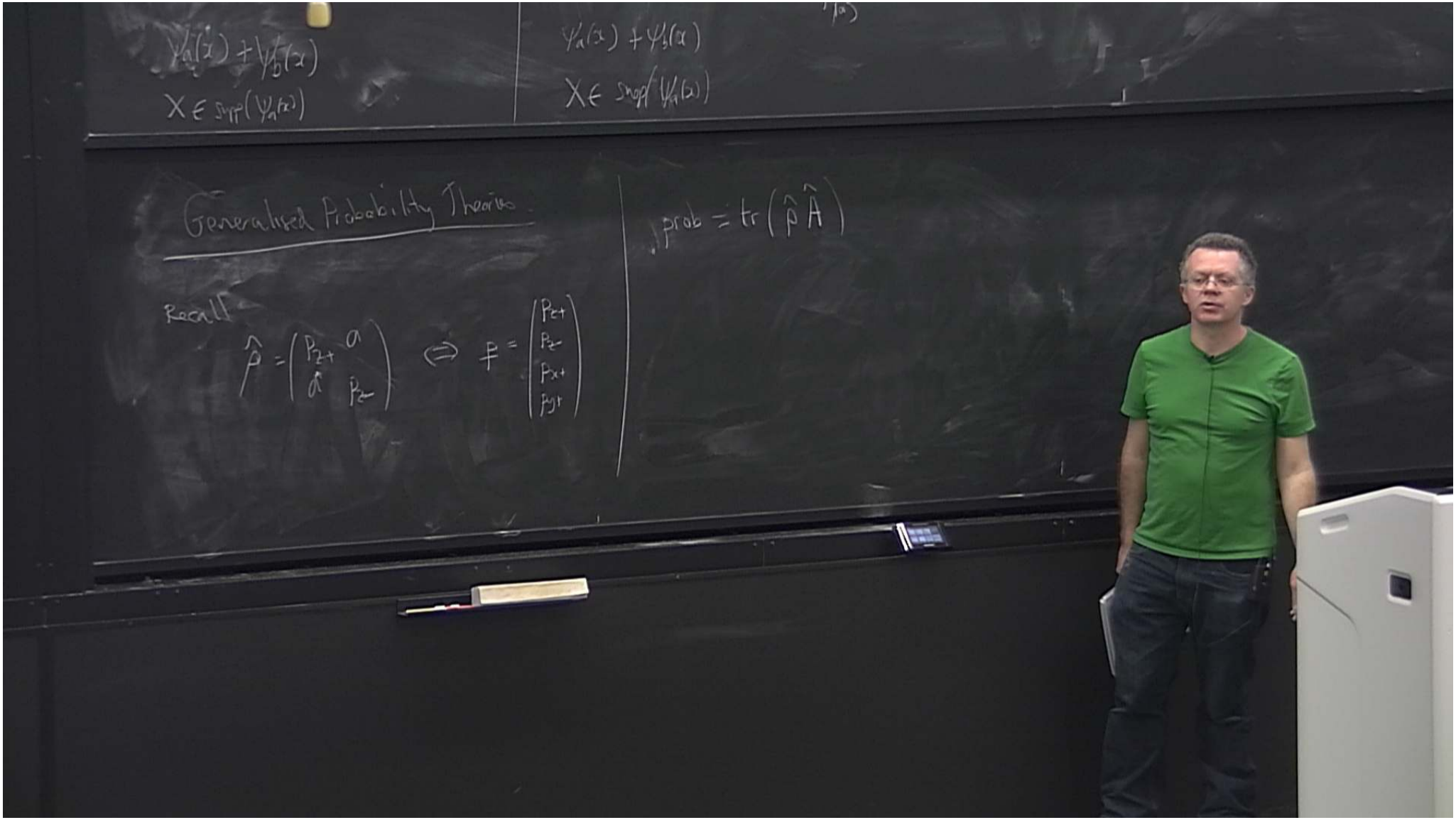
Generalized Probability Theories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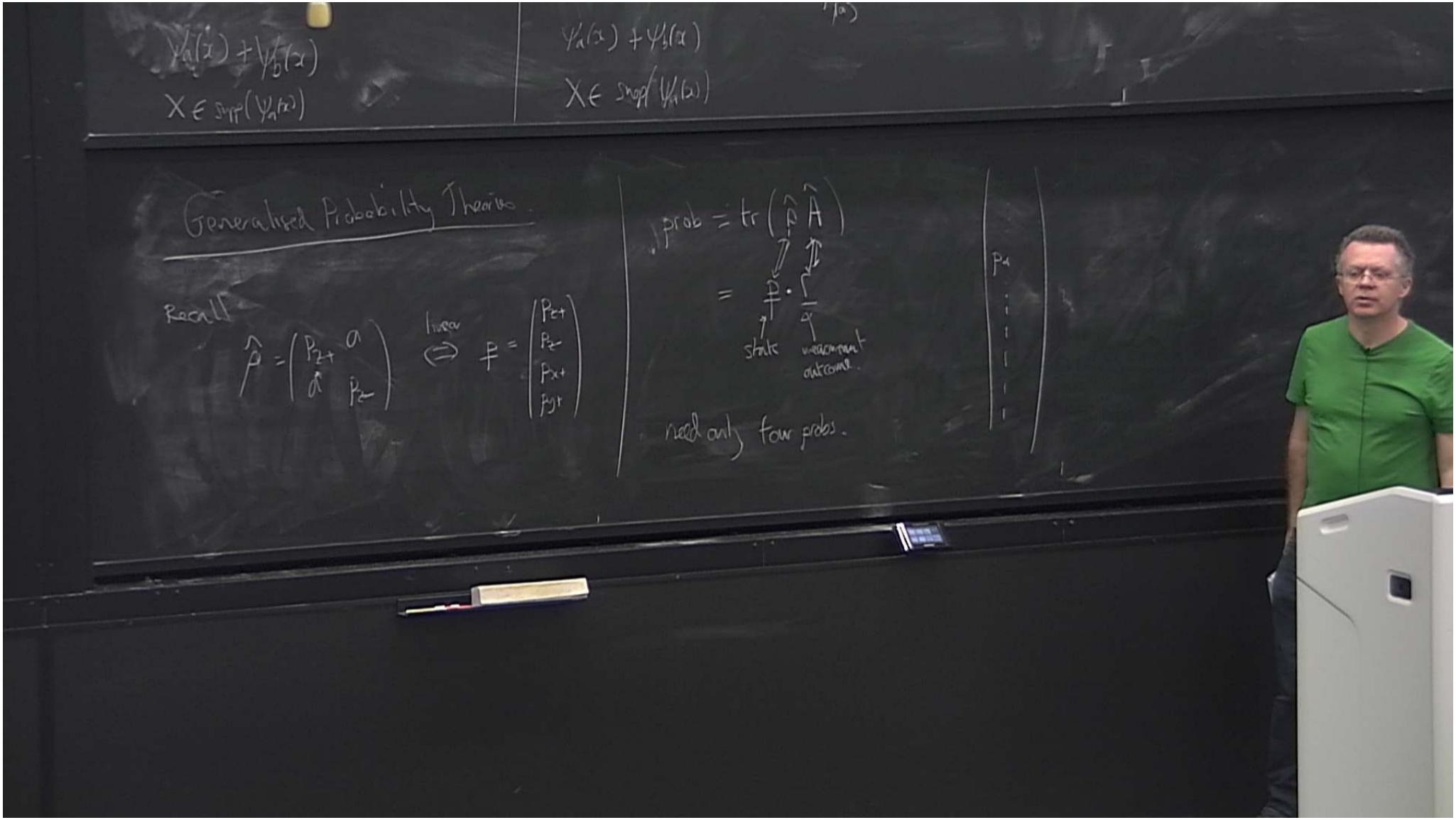
Generalized Probability Theories
Recall
$\hat{\rho} = \begin{pmatrix} P_{z+} & a \\ a^* & P_{z-} \end{pmatrix} \Leftrightarrow \vec{P} = \begin{pmatrix} P_{z+} \\ P_{z-} \\ P_{x+} \\ P_{y+} \end{pmatrix}$
$\mathrm{prob} = \mathrm{tr}(\hat{\rho}\hat{A})$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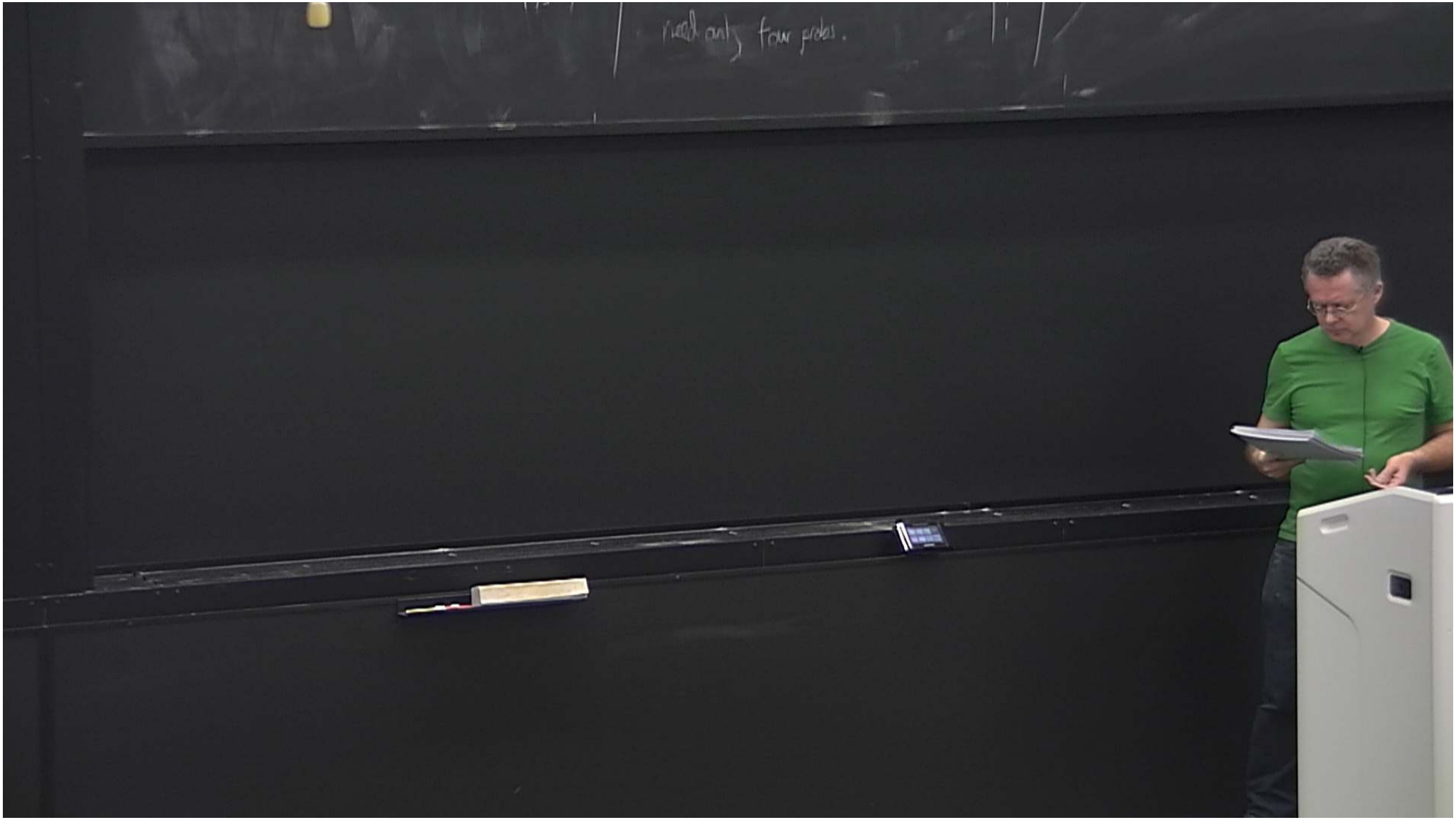
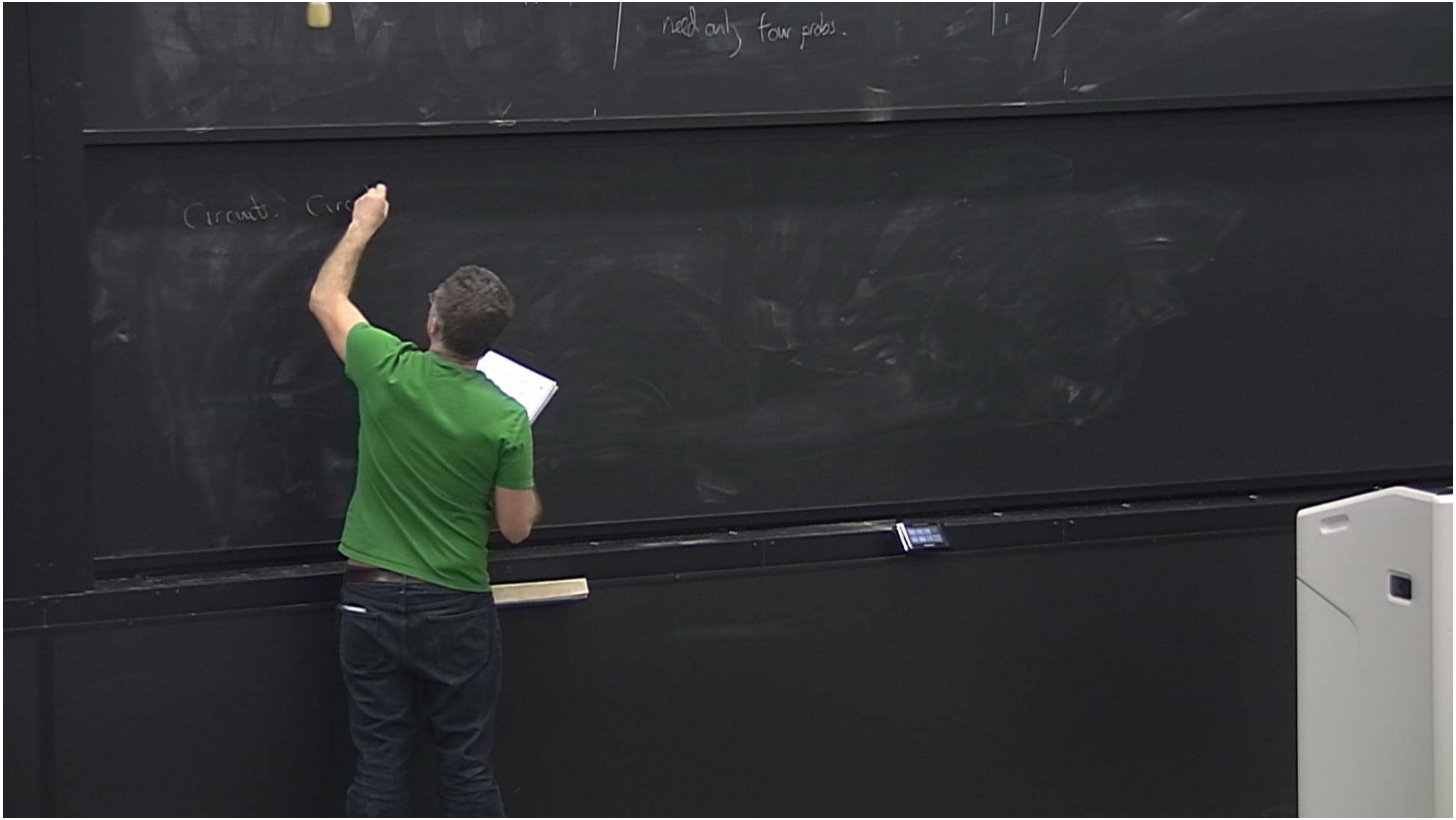
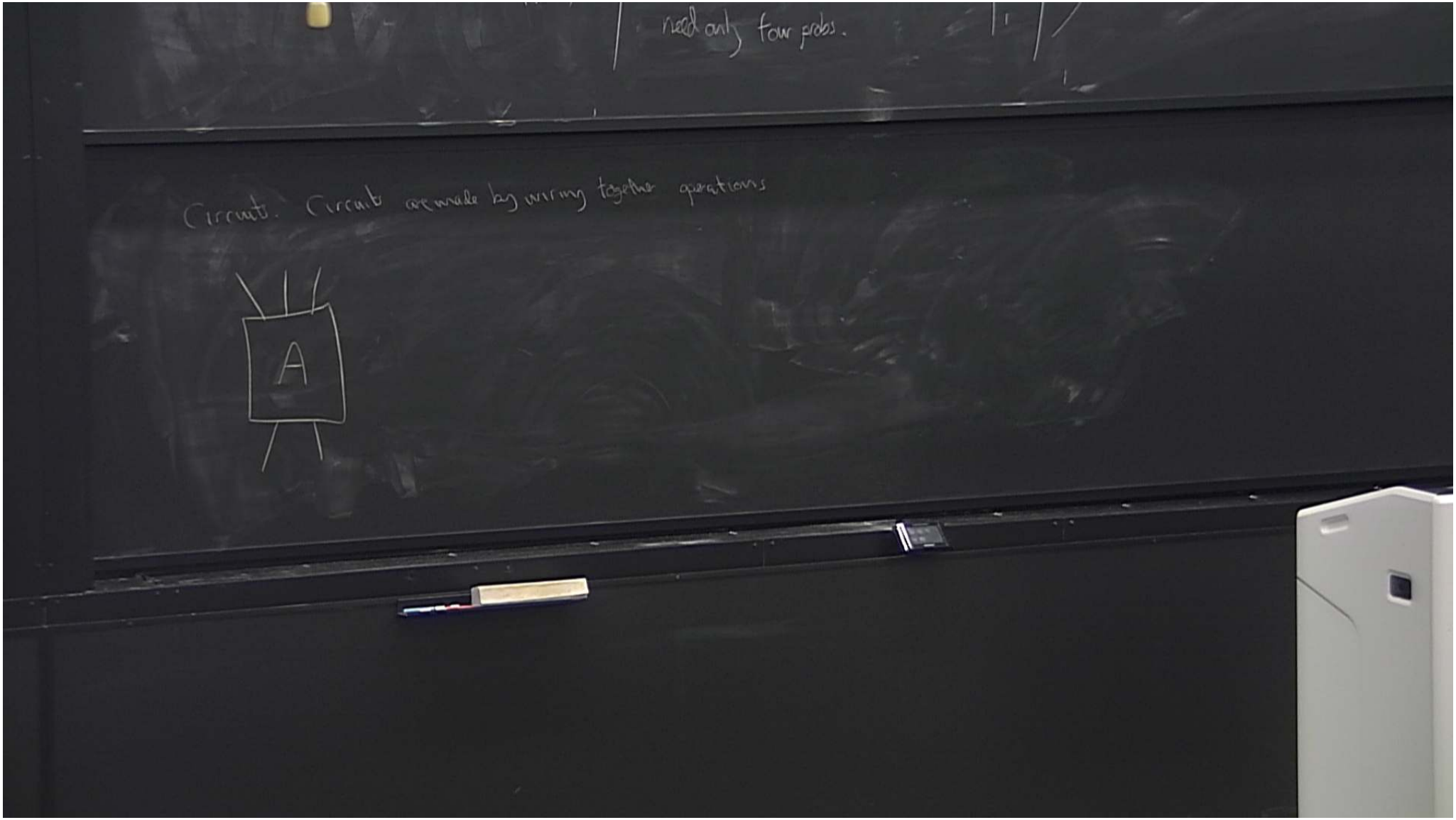
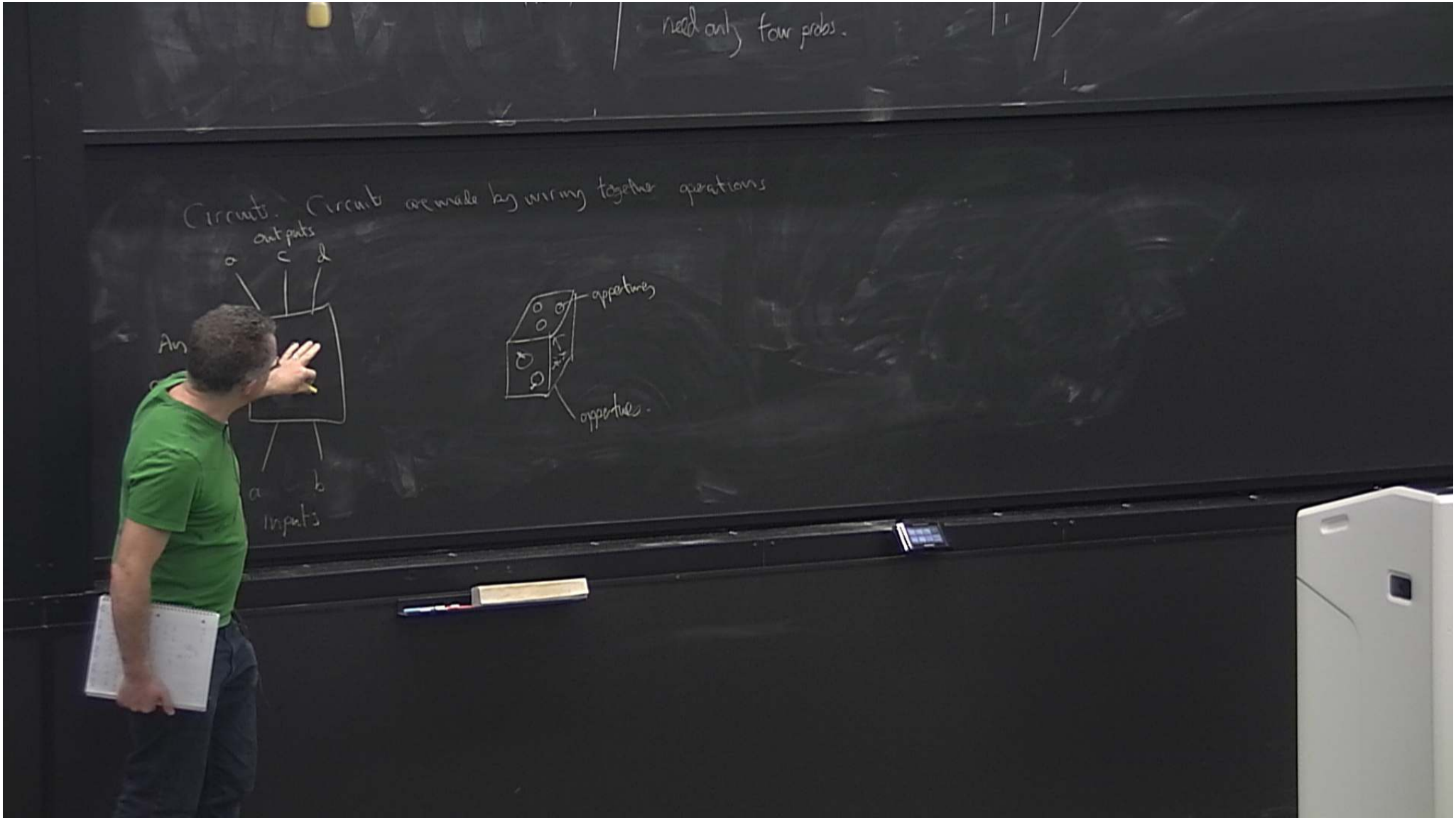
Generalised Probability Theories
Recall
$\hat{\rho} = \begin{pmatrix} p_{z+} & a \\ a^* & p_{z-} \end{pmatrix}$
linear
$\vec{p} = \begin{pmatrix} p_{z+} \\ p_{z-} \\ p_{x+} \\ p_{y+} \end{pmatrix}$
prob $= \text{tr}(\hat{\rho}\hat{A})$
$= \vec{p} \cdot \vec{\alpha}$
state
measurement outcome
need only four probs.
p_4


need only four probes.

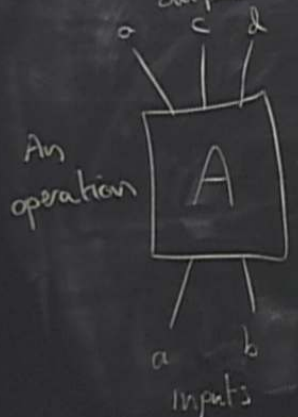

need only four probs.
Circuit.


need only four probs.
Circuits. Circuits are made by wiring together operations
A


need only four probs.
Circuits. Circuits are made by wiring together operations
outputs
a c d
a b
inputs
apperture
apperture.

need only four probs.

Circuits. Circuits are made by wiring together operations



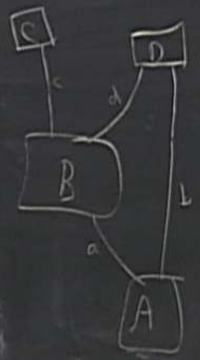
An operation

has a set of outcomes associated with it (generally a subset of the set of all outcomes)

will say that "operation has happened" if the outcome seen is in the set of outcomes associated with the operation.

He then writes $p(\lambda | e(P))$

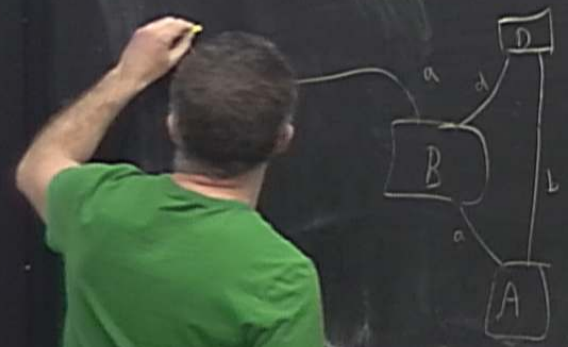
- A circuit. no open inputs or outputs left over



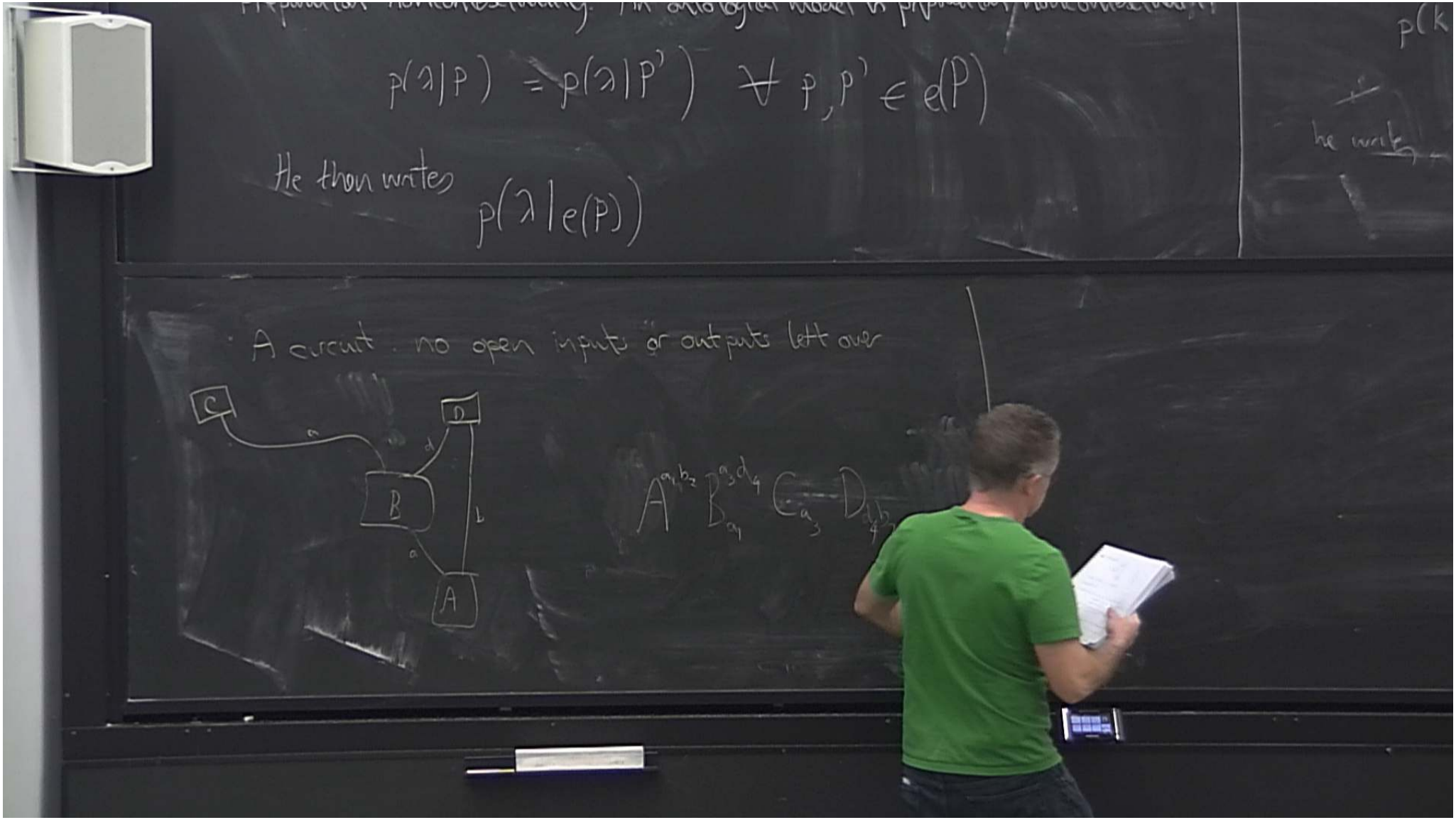
$p(\lambda|P) = p(\lambda|P') \quad \forall P, P' \in e(P)$

He then writes $p(\lambda|e(P))$

A circuit. no open inputs or outputs left over



$A^{a,b_2} B^{a_3,d_4}_{a_1} C_{a_3} D_{d_4,b_2}$


$p(\lambda|P) = p(\lambda|P') \quad \forall P, P' \in e(P)$
He then writes $p(\lambda|e(P))$
A circuit. no open inputs or outputs left over
C
D
B
A
a
d
L
a
$A^{a_1 b_2} B^{a_3 d_4}_{a_1} C_{a_3} D_{\ldots}$

$\forall\, p, p' \in e(P)$

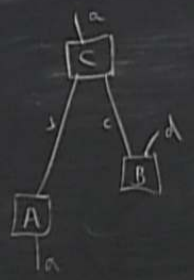
$p(k \mid M, \lambda) = p(k \mid M', \lambda) \quad \forall\, M, M' \in e(M)$

he write

$p(k \mid e(M), \lambda)$

outputs left over

A fragment



have some open inputs/outputs.

A preparation is a fragment having only open outputs

A result is fragment having only open inputs.

$\forall P, P' \in e(P)$

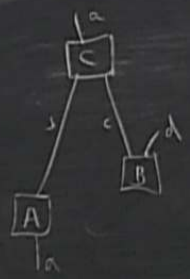
$p(k \mid M, \lambda) = p(k \mid M', \lambda) \quad \forall M, M' \in e(M)$

he write

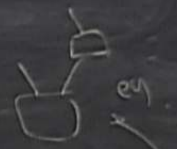
$p(k \mid e(M), \lambda)$

outputs left over

A fragment



have some open inputs/outputs.



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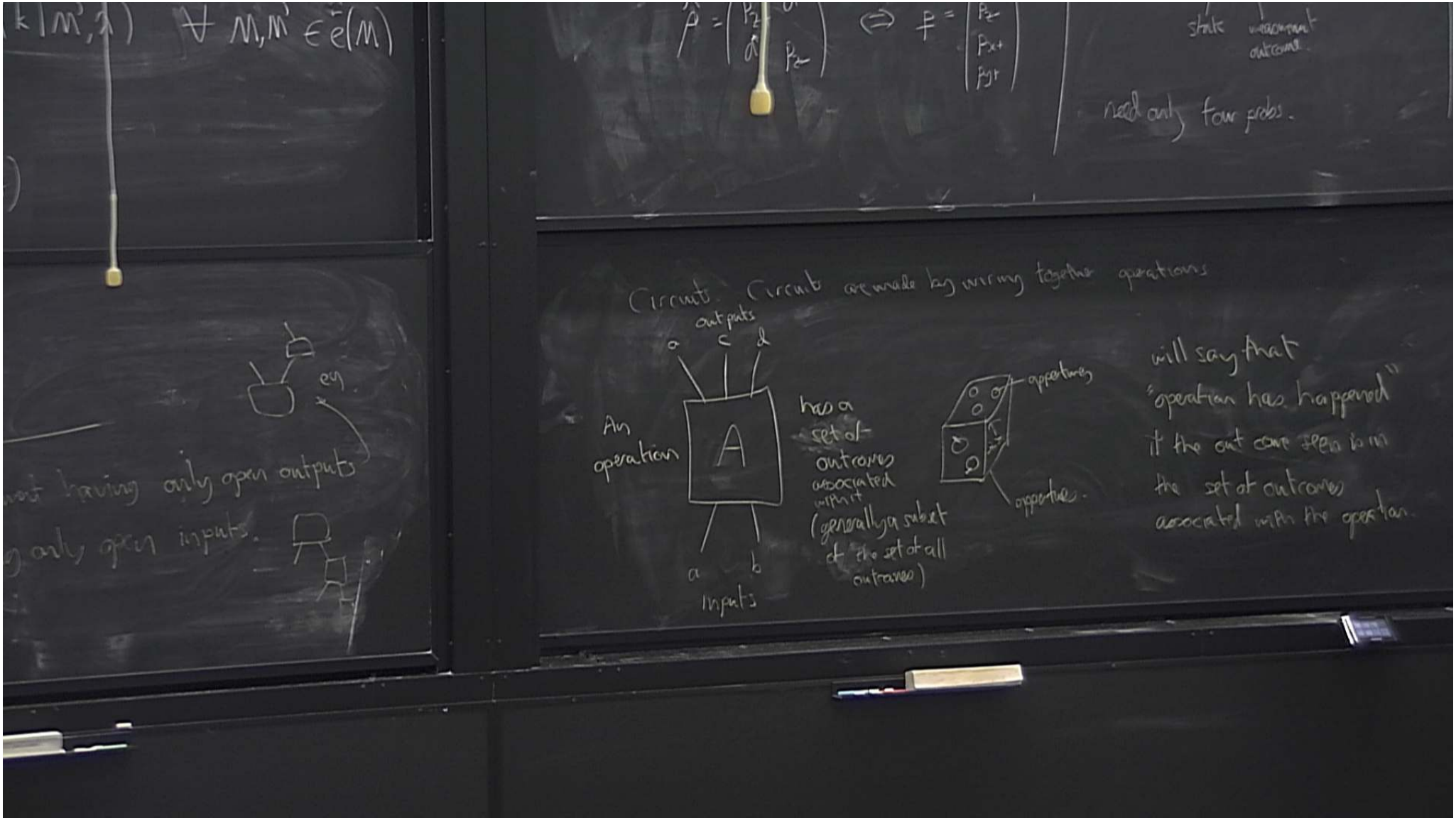
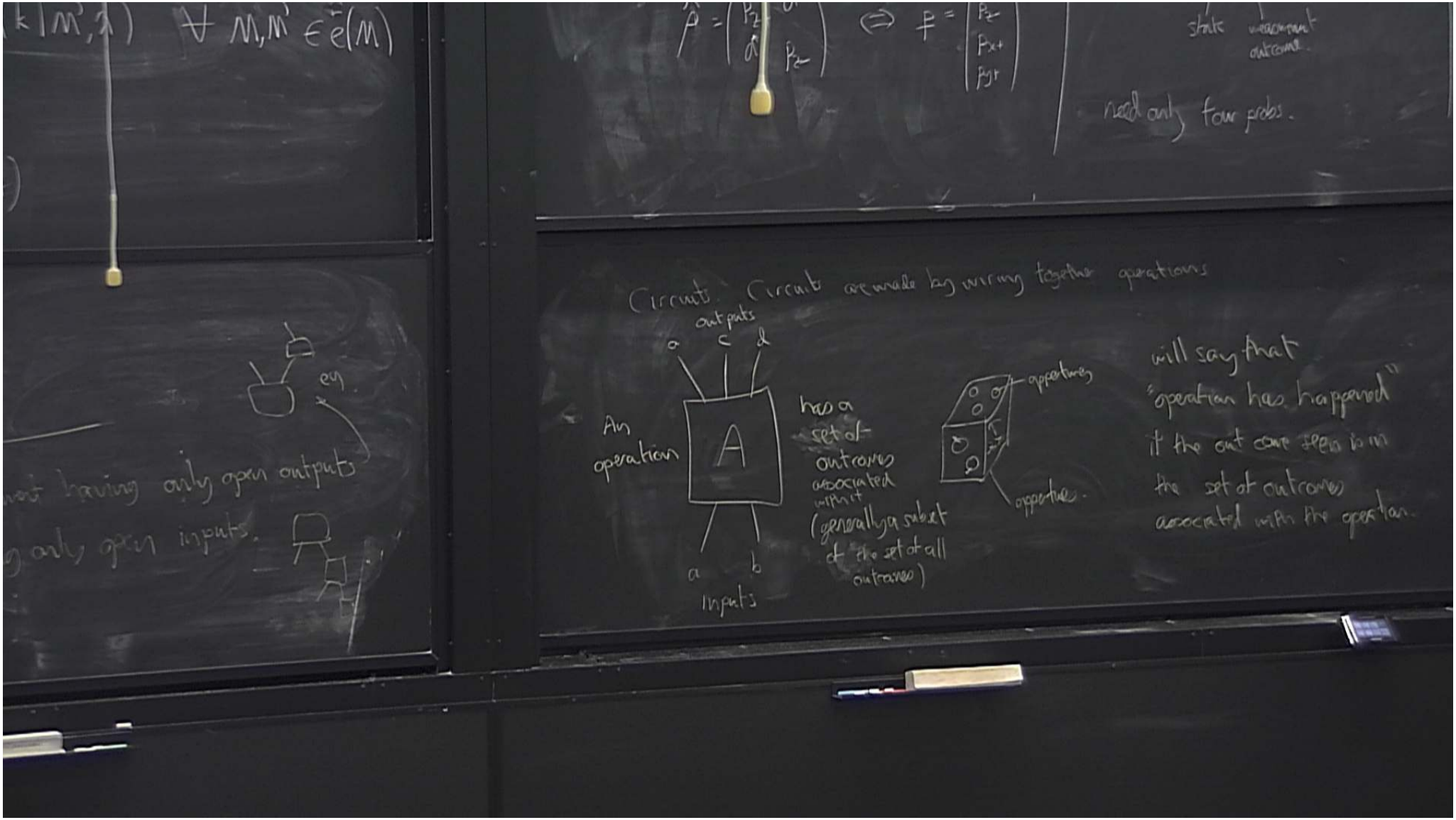

need only four probs.
Circuits. Circuits are made by wiring together operations
outputs
a c d
An operation
A
has a set of outcomes associated with it (generally a subset of the set of all outcomes)
operations
operation.
will say that "operation has happened" if the outcome lies in the set of outcomes associated with the operation.
a b
inputs
only open outputs
only open inputs.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outputs
a
c
d
An operation
A
has a set of outcomes associated with it (generally a subset of the set of all outcomes)
operations
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a
b
Inputs
having only open outputs
only open inputs.