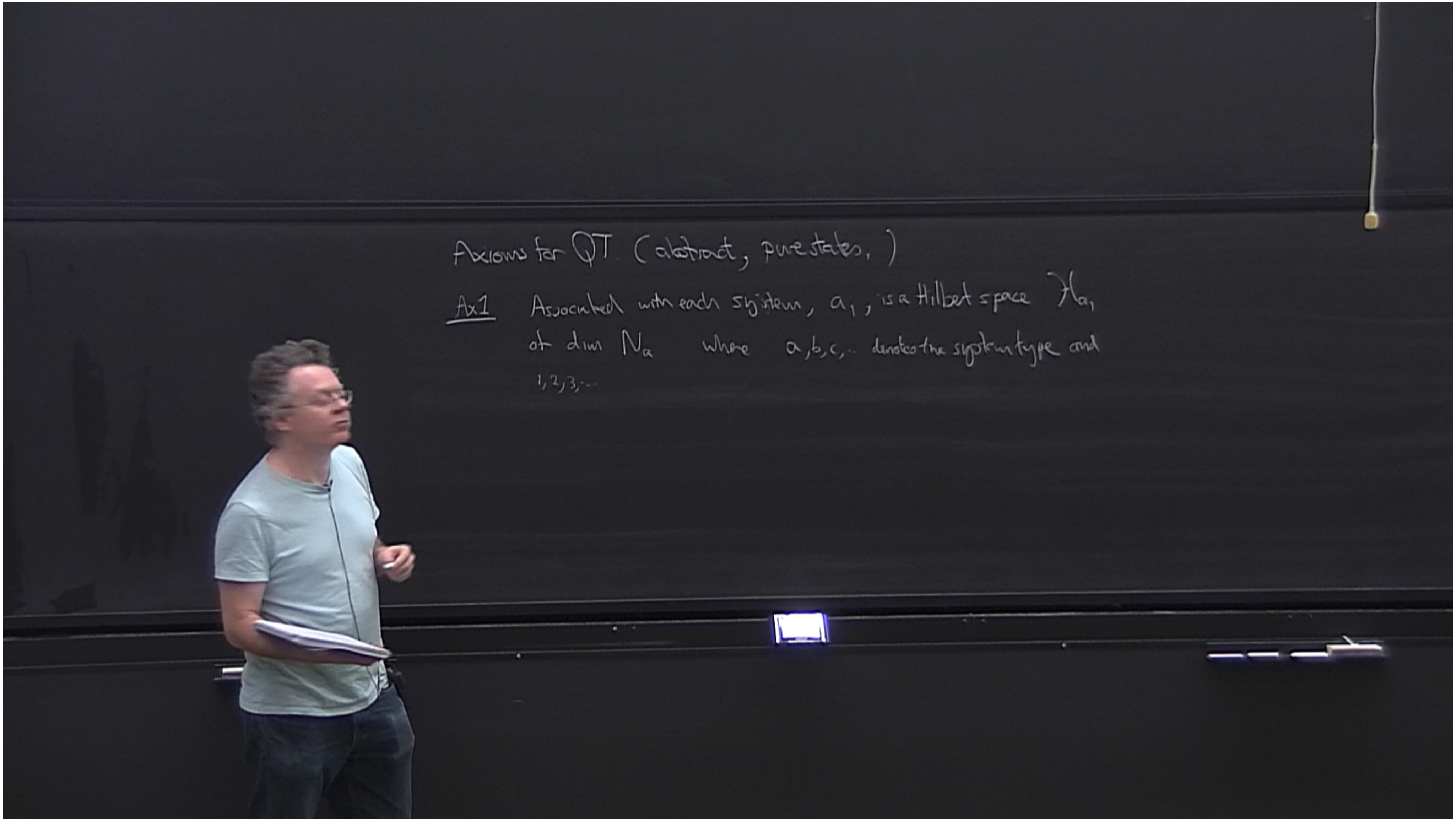
Title: Foundations of Quantum Mechanics-2

Date: Jan 06, 2015 11:30 AM

URL: http://pirsa.org/15010039

Abstract:


Axioms for QT (abstract, pure states,)
Ax1 Associated with each system, a_1, is a Hilbert space $\mathcal{H}_{a_1}$
of dim N_a where a, b, c, .. denotes the system type and
1, 2, 3, ...

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<u>Ax2</u> For a composite system (e.g. $a_1 a_2 b_3 c_4$) the associated Hilbert space is the tensor product (e.g. $\mathcal{H}_{a_1} \otimes \mathcal{H}_{a_2} \otimes \mathcal{H}_{b_3} \otimes \mathcal{H}_{c_4}$)

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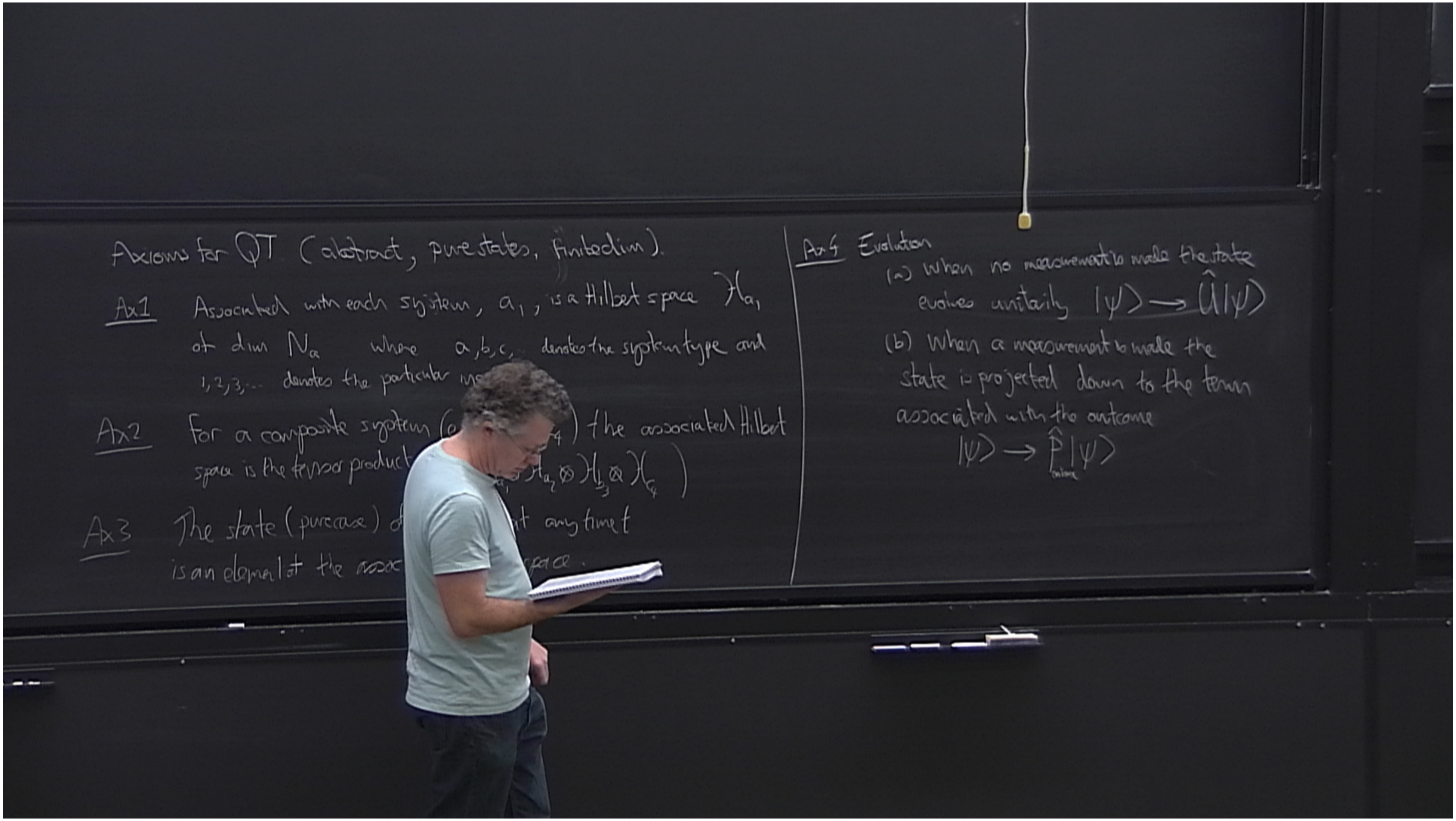
<u>Ax3</u> The state (pure case) of a system at any time t is an element of the associated Hilbert space.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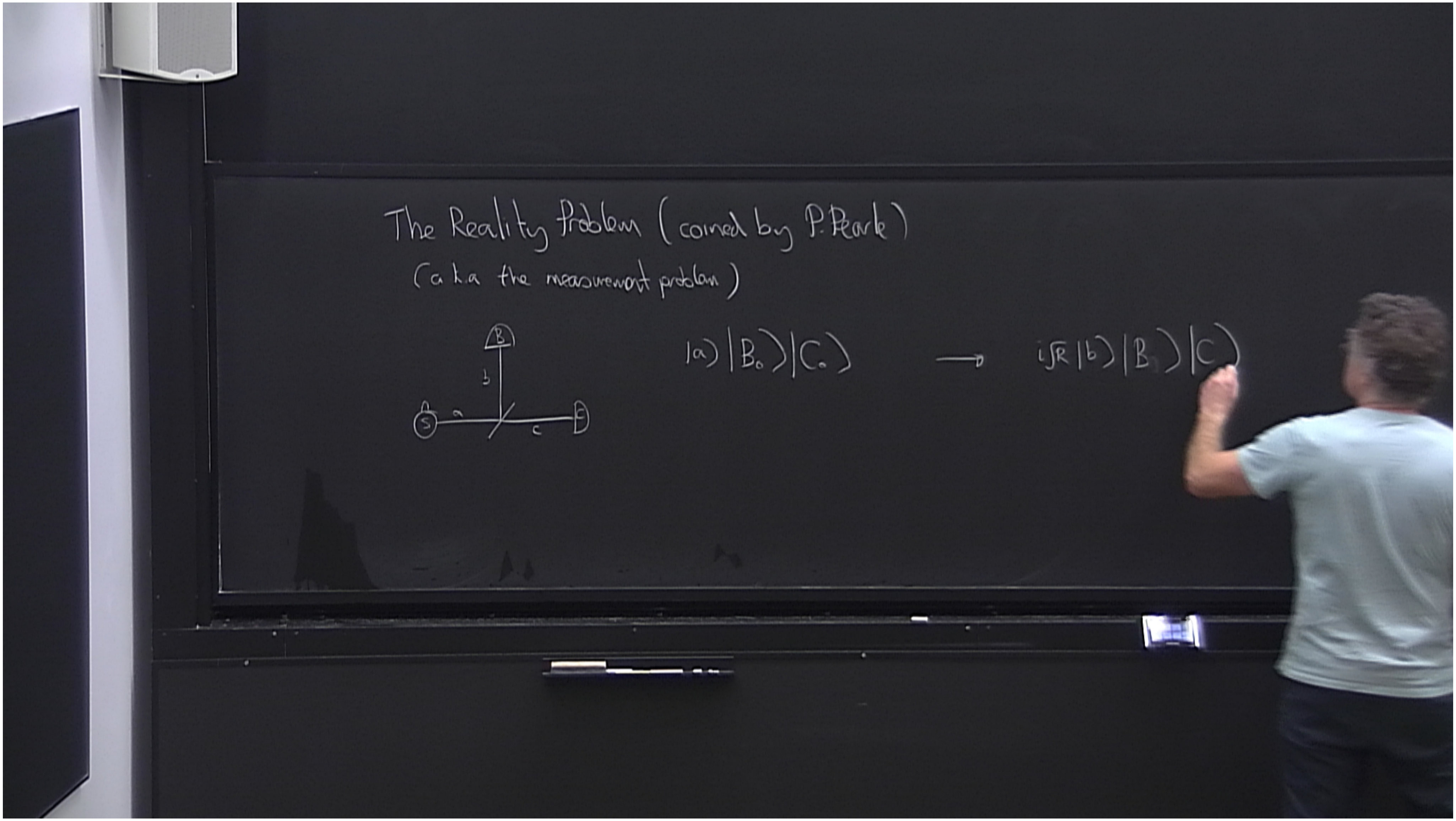
is an element of the assoc
Ax4 Evolution
(a) When no measurement is made the state
evolves unitarily $|\psi\rangle \rightarrow \hat{U}|\psi\rangle$
(b) When a measurement is made the
state is projected down to the term
associated with the outcome
$|\psi\rangle \rightarrow \hat{P}|\psi\rangle$


The Reality Problem (coined by P. Pearle)
(a.k.a the measurement problem)
B
b
S
a
c
E
|a⟩ |B₀⟩ |C₀⟩ → i√R |b⟩ |B⟩ |C⟩

The Reality Problem (coined by P. Pearle)

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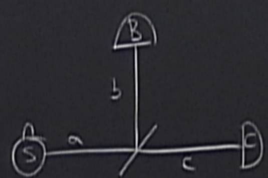

$$|a\rangle|B_0\rangle|C_0\rangle \longrightarrow i\sqrt{R}\,|B\rangle|C_0\rangle + \sqrt{T}\,|B_0\rangle|C\rangle$$

$$\longrightarrow i\sqrt{R}\,|B\rangle|C_0\rangle$$

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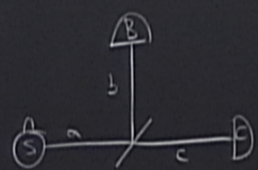
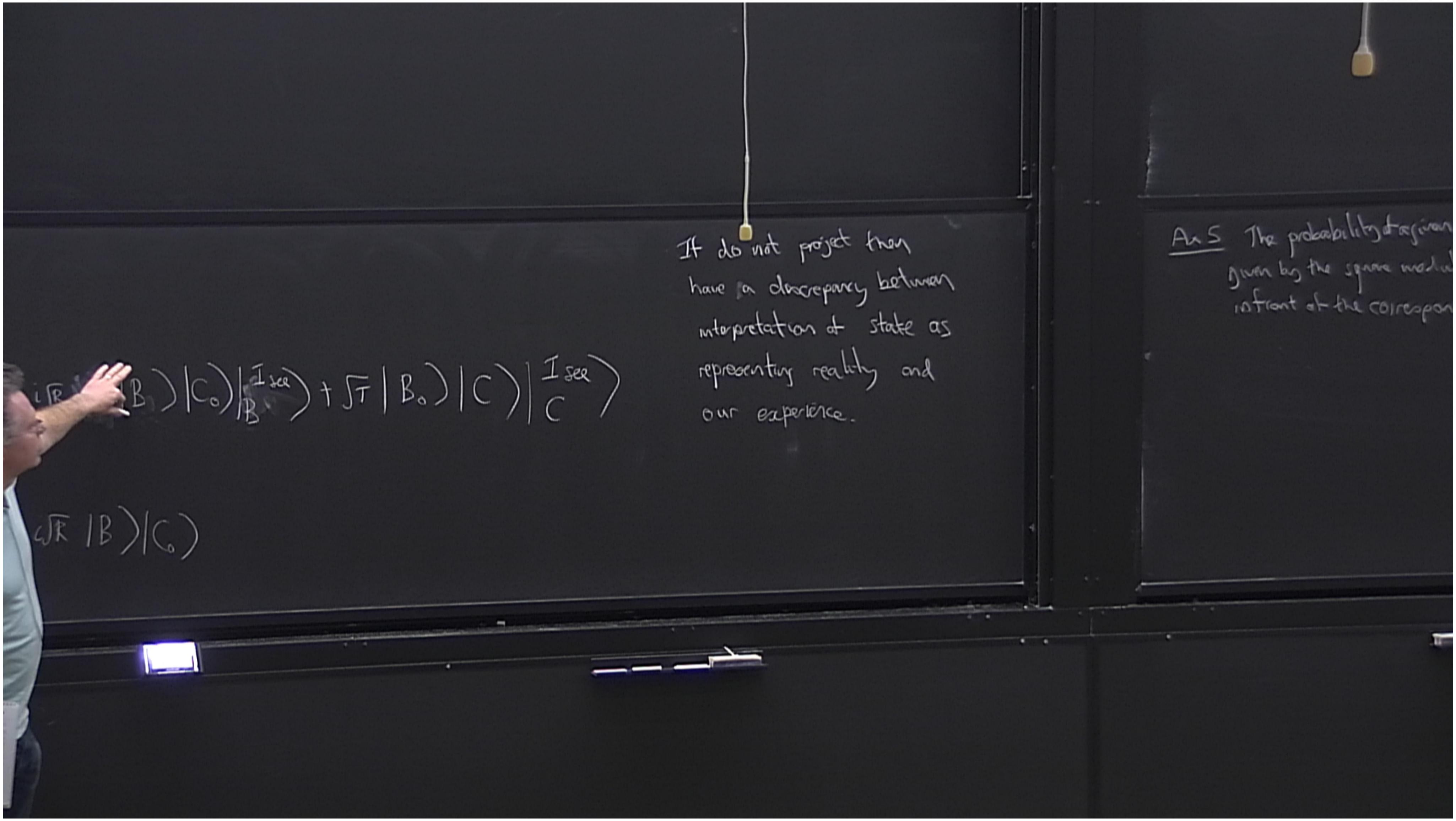
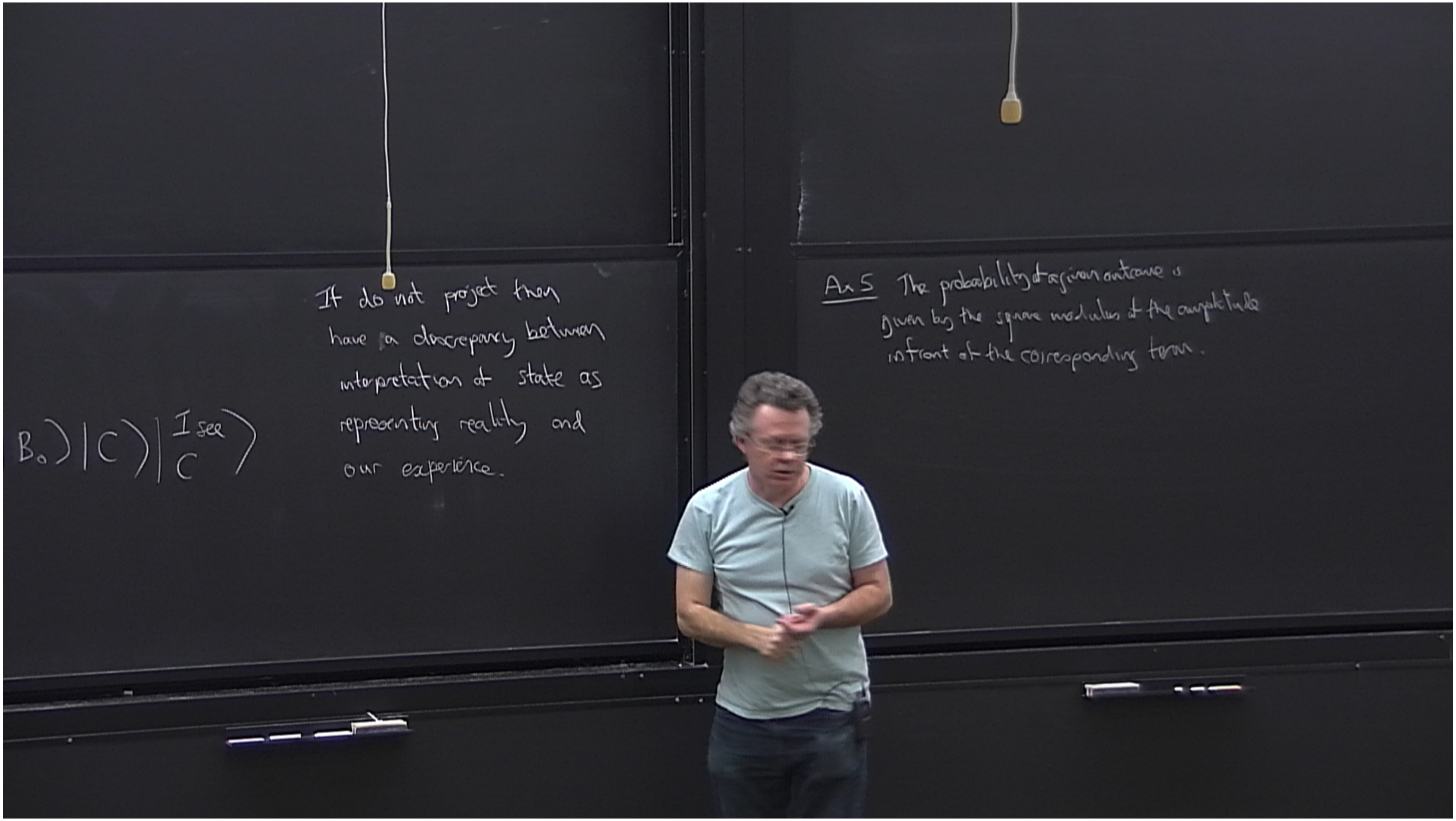


$$|a\rangle|B_0\rangle|C_0\rangle|Me\rangle \longrightarrow i\sqrt{R}\,|B\rangle|C_0\rangle\left|{}^{\text{I see}}_{B}\right\rangle + \sqrt{T}\,|B_0\rangle|C\rangle\left|{}^{\text{I see}}_{C}\right\rangle$$

$$\longrightarrow i\sqrt{R}\,|B\rangle|C_0\rangle$$


If do not project then
have a discrepancy between
interpretation of state as
representing reality and
our experience.


B₀)|C)|I see C)
If do not project then
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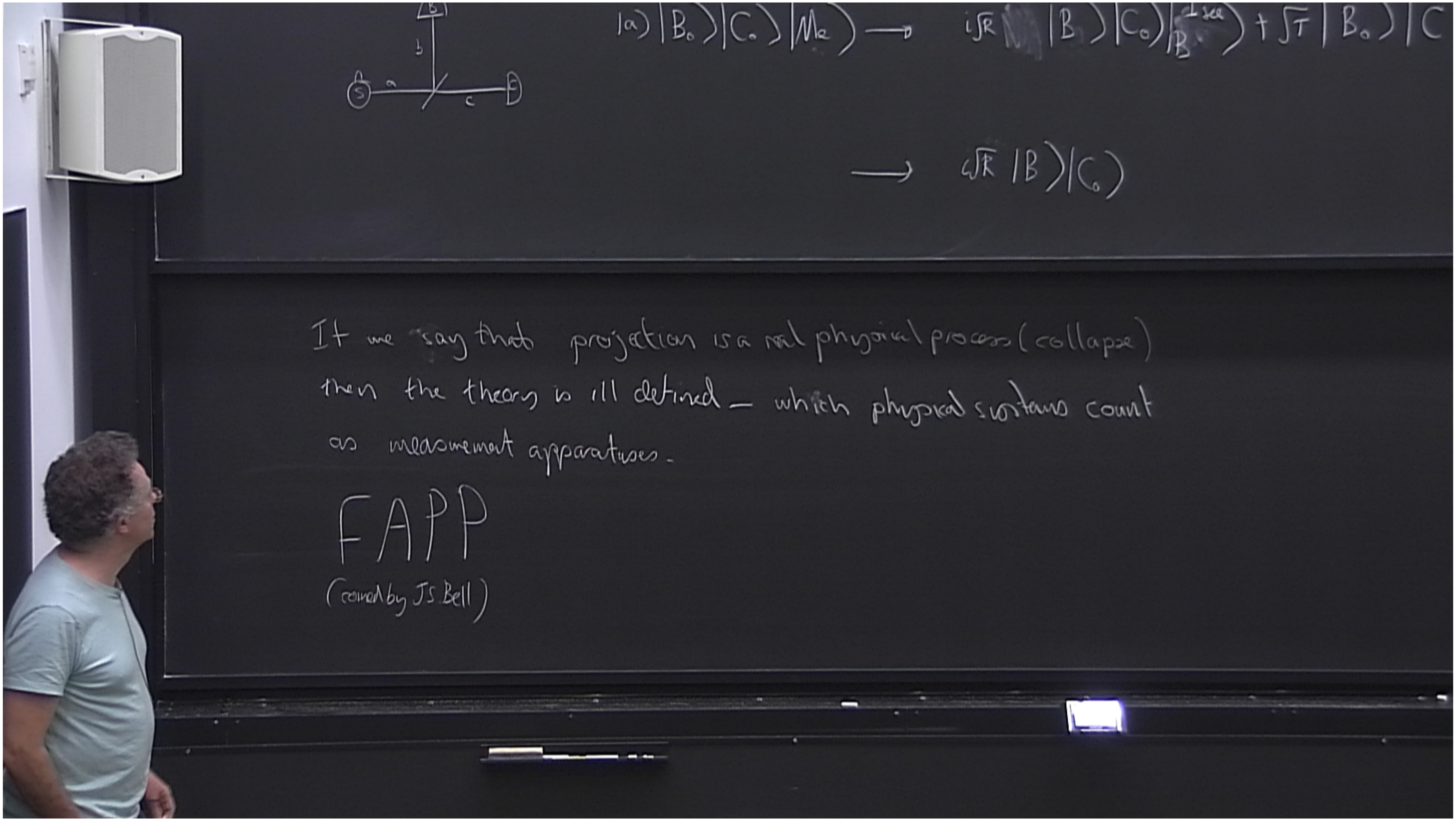
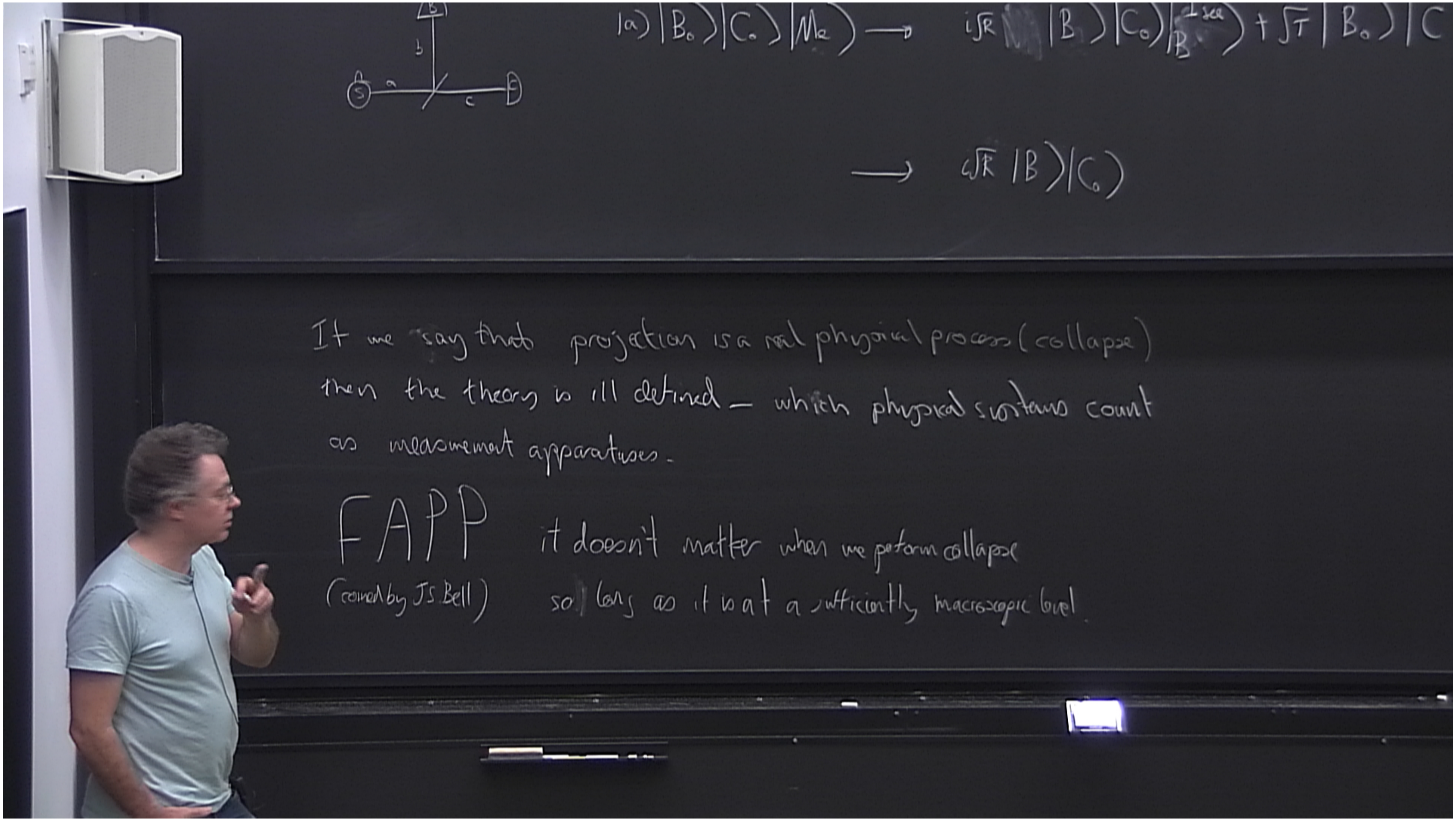
Ax 5 The probability of a given outcome is
given by the square modulus of the amplitude
in front of the corresponding term.


If we say that projection is a real physical process (collapse)
then the theory is ill defined — which physical systems count
as measurement apparatuses.
FAPP
(coined by J.S. Bell)


$|a\rangle|B_0\rangle|C_0\rangle|M_e\rangle \longrightarrow i\sqrt{R}\,|B\rangle|C_0\rangle|B\rangle + \sqrt{T}\,|B_0\rangle|C$
$\longrightarrow i\sqrt{R}\,|B\rangle|C_0\rangle$
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it doesn't matter when we perform collapse
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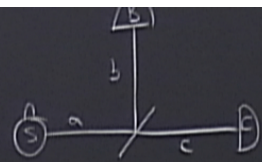

$$|a\rangle|B_0\rangle|C_0\rangle|M_e\rangle \longrightarrow i\sqrt{R}\,|B\rangle|C_0\rangle|{}_{B}^{1\,\text{sec}}\rangle + \sqrt{T}\,|B_0\rangle|C$$

$$\longrightarrow i\sqrt{R}\,|B\rangle|C_0\rangle$$

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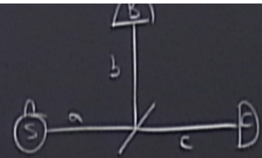

$$|a\rangle|B_0\rangle|C_0\rangle|M_R\rangle \longrightarrow i\sqrt{R}\,|B\rangle|C_0\rangle|B\text{ see}\rangle + \sqrt{T}\,|B_0\rangle|C$$

$$\longrightarrow \sqrt{R}\,|B\rangle|C_0\rangle$$

If we say that projection is a real physical process (collapse) then the theory is ill defined — which physical systems count as measurement apparatuses.

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Two components to

① What is the

why not $\frac{1}{\sqrt{2}}\big(|$

② What picks

(what gives

$\rangle |M_e\rangle \longrightarrow i\sqrt{R}\,|B\rangle|C_0\rangle\left|{}^{I\ \text{see}}_{B}\right\rangle + \sqrt{T}\,|B_0\rangle|C\rangle\left|{}^{I\ \text{see}}_{C}\right\rangle$

representing reality and our experience.

$\longrightarrow i\sqrt{R}\,|B\rangle|C_0\rangle$

real physical process (collapse)

which physical systems count

when we perform collapse

at a sufficiently macroscopic level

Two components to reality problem.

① What is the basis wrt which we see definite outcomes.

why not $\frac{1}{\sqrt{2}}\left(\left|{}^{I\ \text{see}}_{C}\right\rangle \pm \left|{}^{I\ \text{see}}_{D}\right\rangle\right)$ answered by decoherence.

② What picks out a particular outcome in a particular run (what gives rise to the observation that a particular outcome is seen)

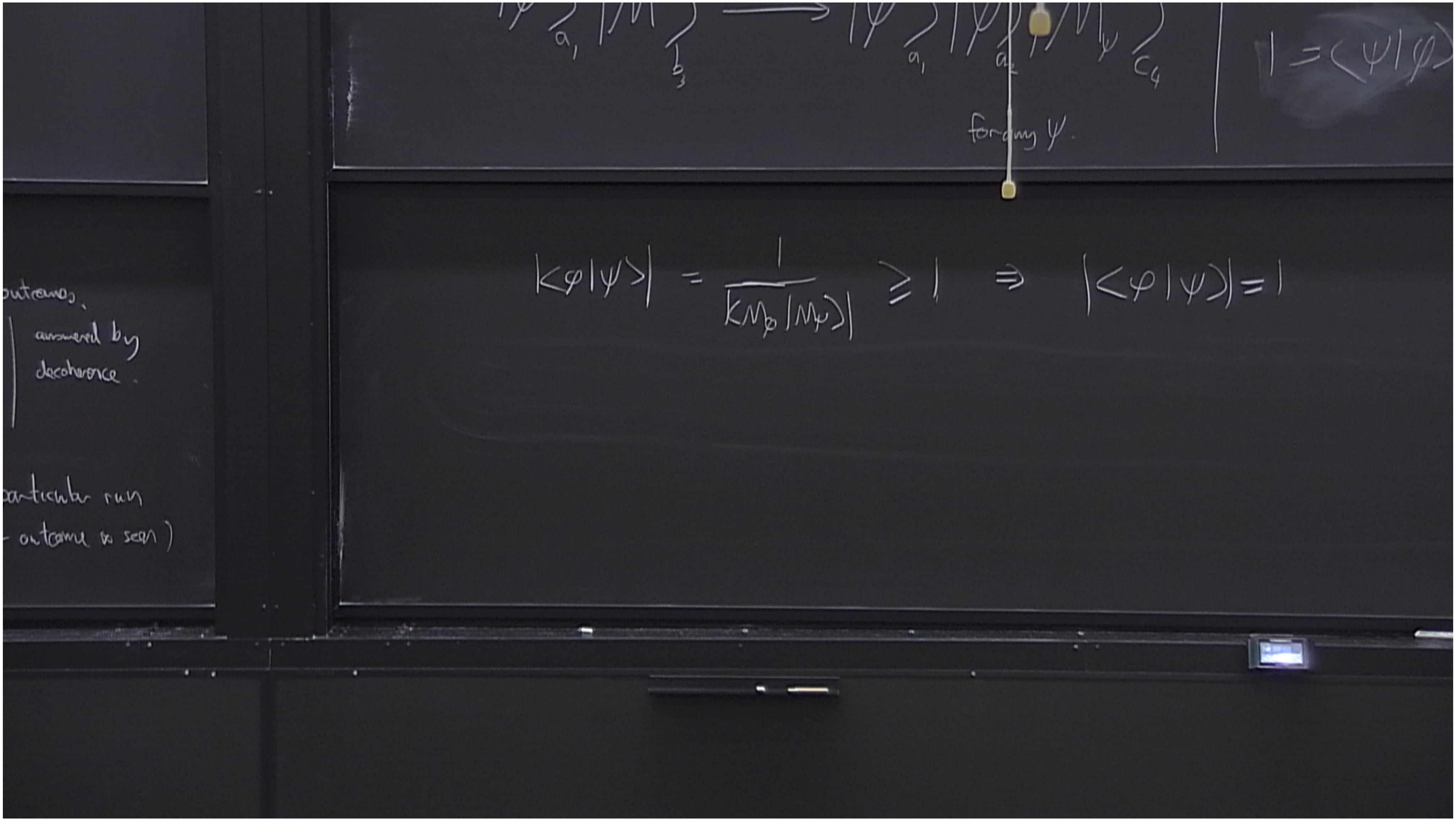
The no cloning theorem.

Imagine we have a machine M that clones states

$$|\psi\rangle_{a_1} |M\rangle_{b_3} \xrightarrow{U} |\psi\rangle_{a_1} |\psi\rangle_{a_2} |M_\psi\rangle_{c_4}$$

for any ψ.

$|\varphi\rangle_{a}, |$


for any ψ.
|⟨φ|ψ⟩| = 1/|⟨M_φ|M_ψ⟩| ≥ 1 ⇒ |⟨φ|ψ⟩| = 1
answered by decoherence.
particular run
outcome is seen)

...outcomes.

answered by decoherence.

particular run

(... outcome is seen)

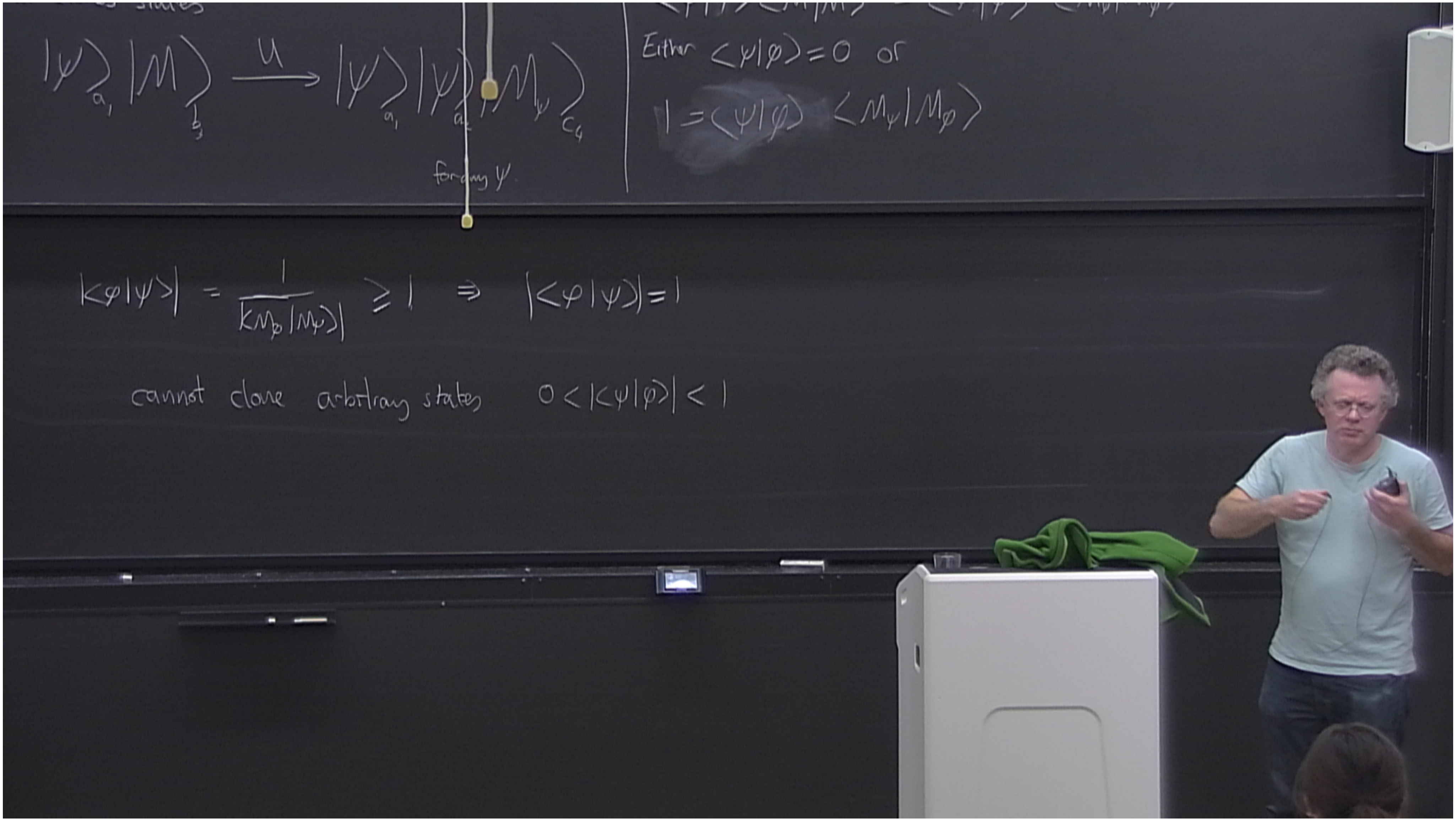
$$|\psi\rangle_{a_1}|M\rangle_{b_3} \longrightarrow |\psi\rangle_{a_1}|\psi\rangle_{a_2}|M_\psi\rangle_{c_4}$$

for any ψ.

$1 = \langle\psi|\varphi\rangle$

$$|\langle\varphi|\psi\rangle| = \frac{1}{|\langle M_\varphi|M_\psi\rangle|} \geq 1 \Rightarrow |\langle\varphi|\psi\rangle| = 1$$

cannot clone arbitrary states $\quad 0 < |\langle\psi|\varphi\rangle| < 1$



$|\psi\rangle_{a_1}|M\rangle_{b_3} \xrightarrow{U} |\psi\rangle_{a_1}|\psi\rangle_{a_2}|M_\psi\rangle_{c_4}$
for any ψ.
Either $\langle\psi|\varphi\rangle = 0$ or
$1 = \langle\psi|\varphi\rangle \langle M_\psi|M_\varphi\rangle$
$|\langle\varphi|\psi\rangle| = \frac{1}{|\langle M_\varphi|M_\psi\rangle|} \geq 1 \Rightarrow |\langle\varphi|\psi\rangle| = 1$
cannot clone arbitrary states $0 < |\langle\psi|\varphi\rangle| < 1$