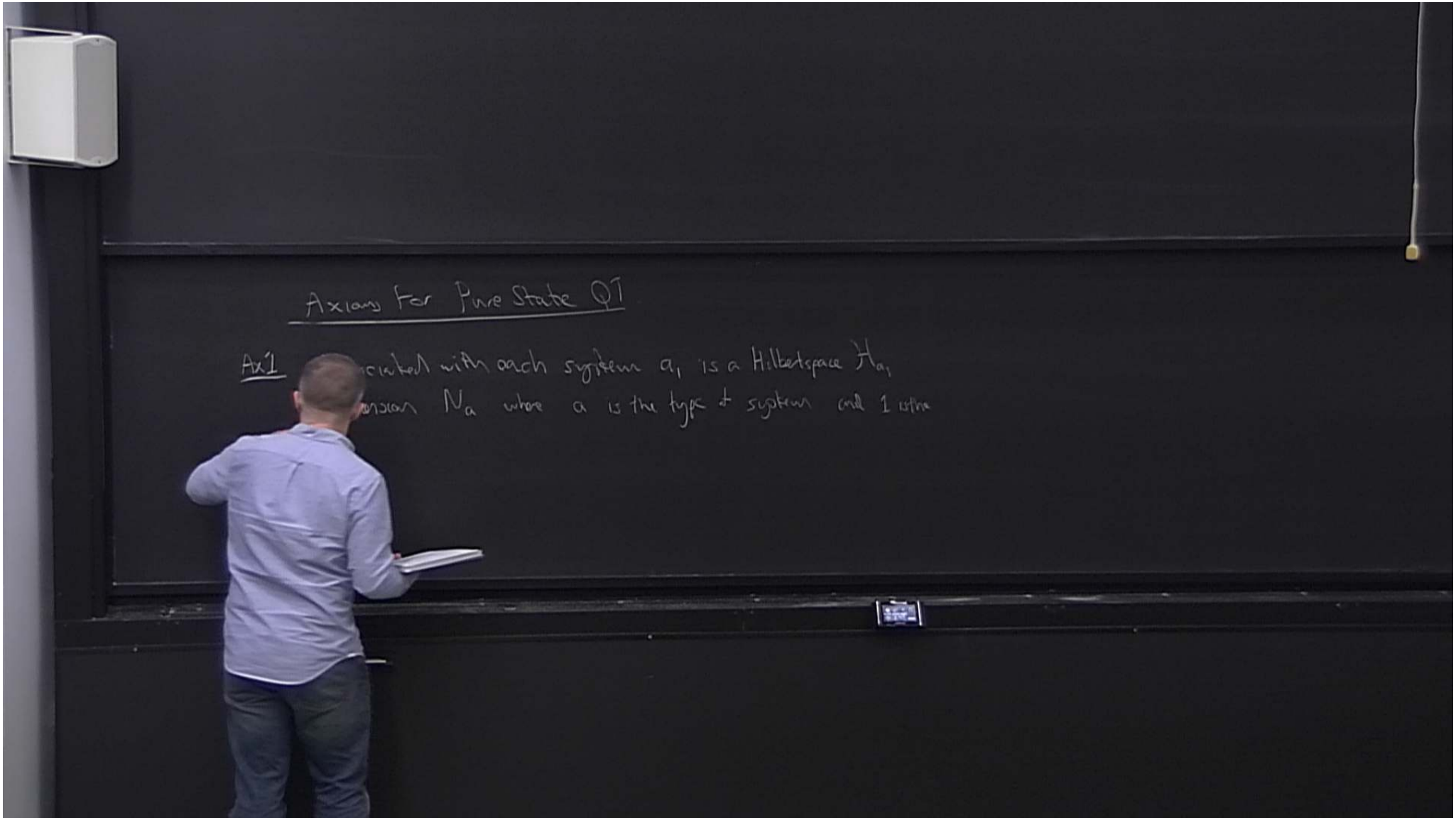
Title: PSI 2015/2016 Foundations of Quantum Mechanics - Lecture 2

Date: Jan 05, 2016 11:30 AM

URL: http://pirsa.org/16010055

Abstract:


Axioms For Pure State QT
Ax1
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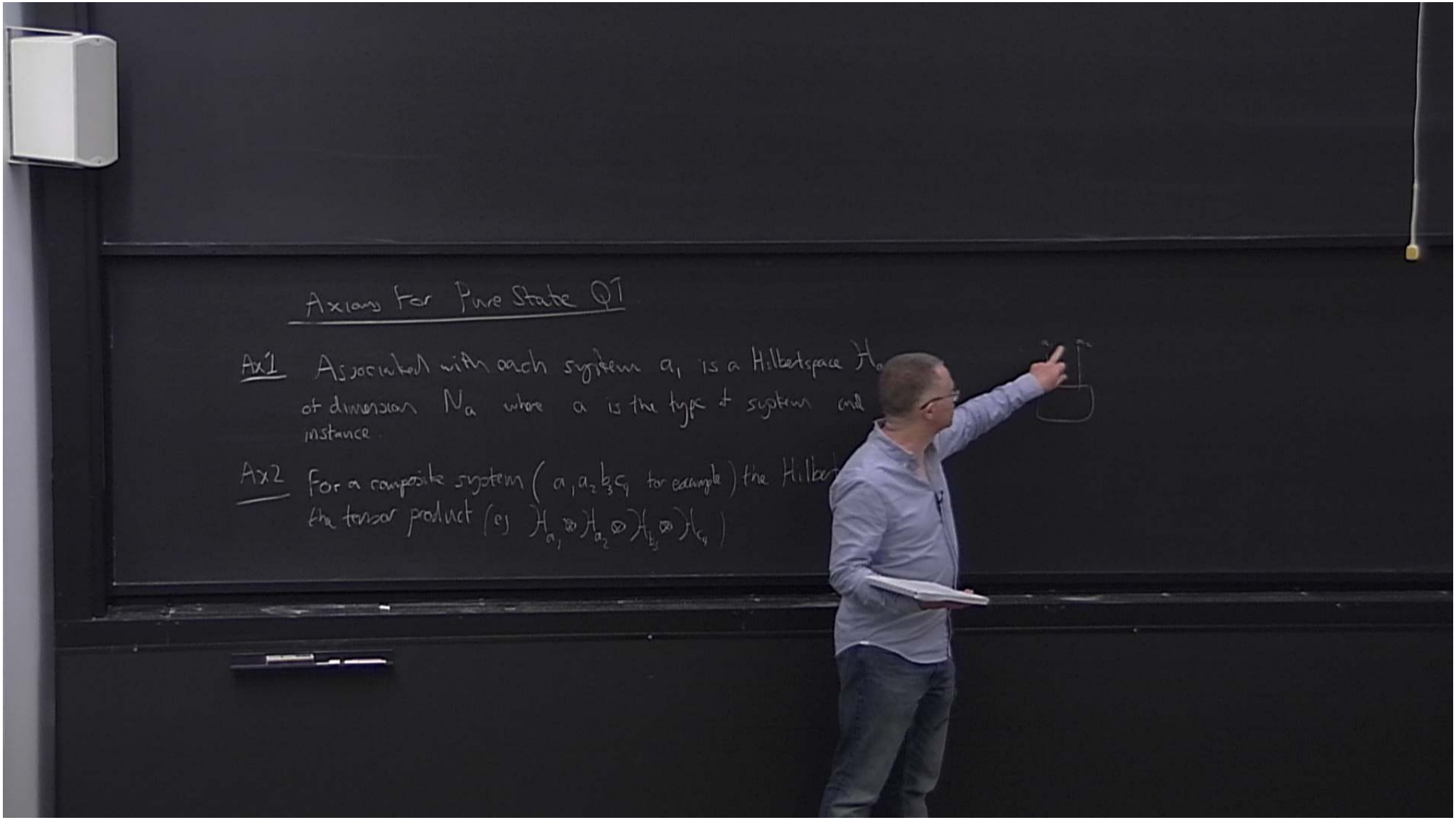
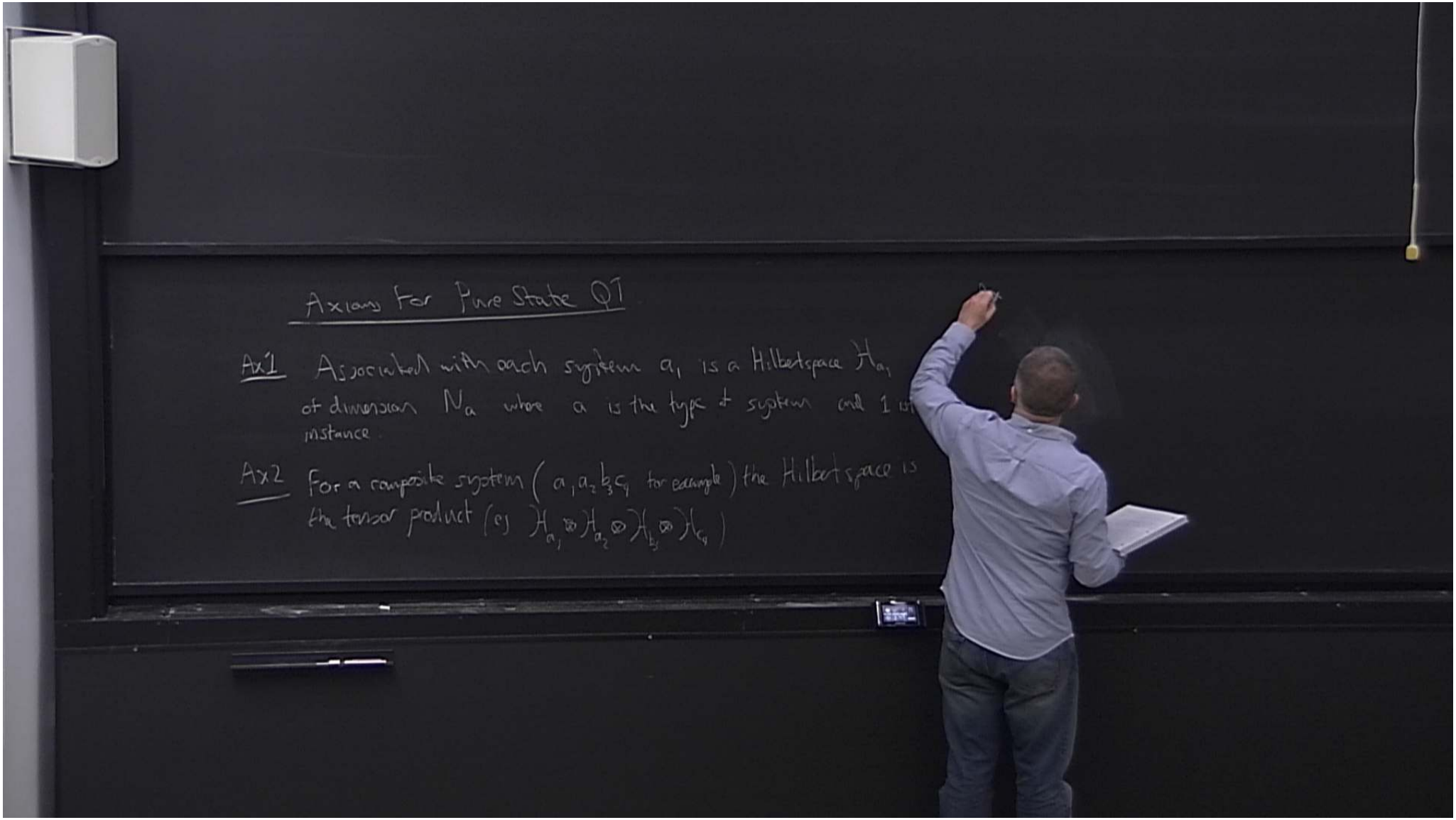

Axioms For Pure State QT
Ax1 Associated with each system a_i is a Hilbertspace $\mathcal{H}_a$
of dimension N_a where a is the type of system and
instance
Ax2 For a composite system ($a_1 a_2 b_3 c_4$ for example) the Hilbert
the tensor product (e.g. $\mathcal{H}_{a_1} \otimes \mathcal{H}_{a_2} \otimes \mathcal{H}_{b_3} \otimes \mathcal{H}_{c_4}$)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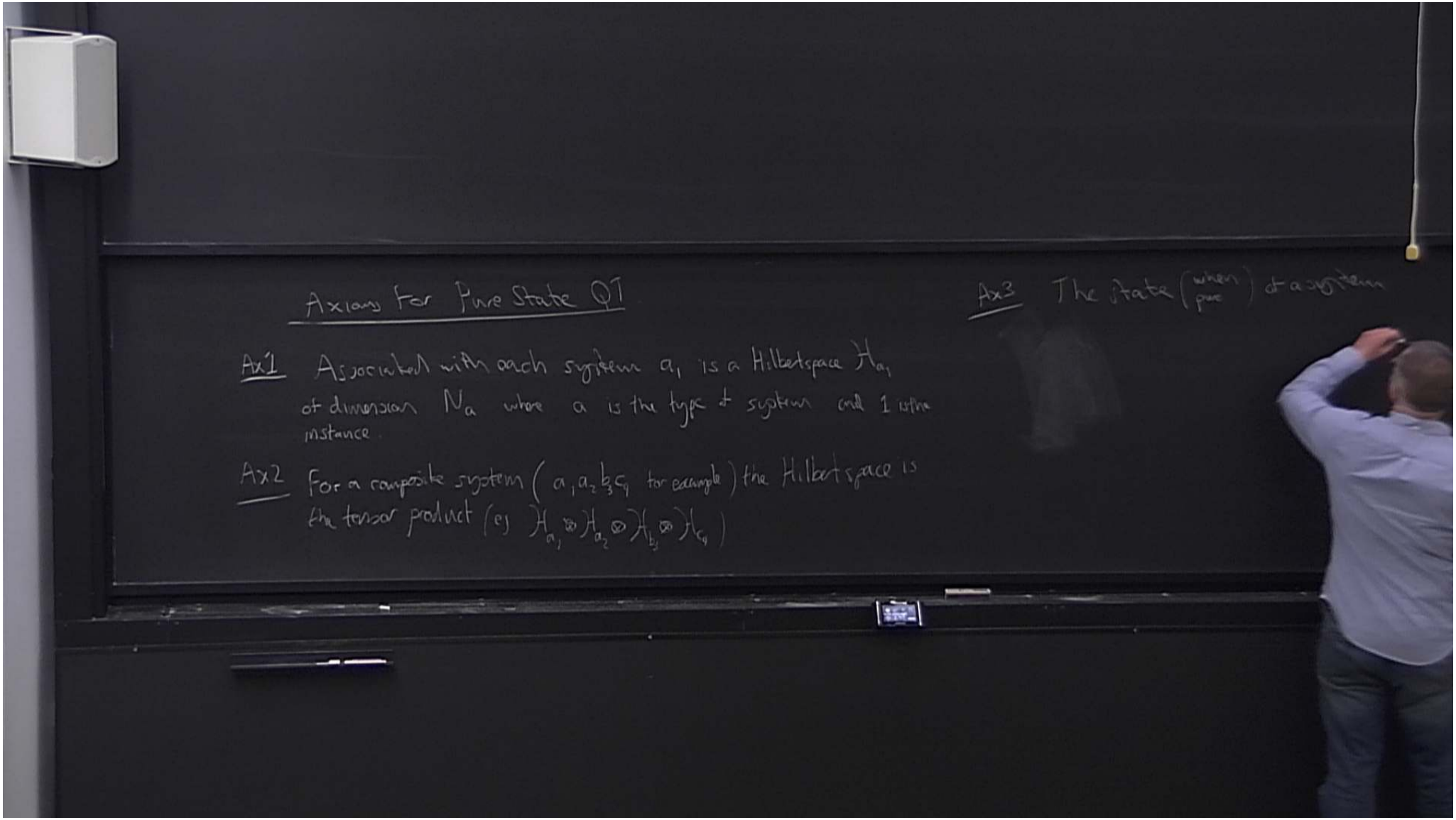
Axioms For Pure State QT
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Ax3 The state (when pure) of a system

Ax1 Associated with each system a_1 is a Hilbertspace $\mathcal{H}_{a_1}$ of dimension N_a where a is the type of system and 1 is the instance

$|\psi\rangle \in \mathcal{H}$

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Ax4 Evolution

(a) When no measurement is made the state evolves unitarily $|\psi\rangle \rightarrow \hat{U}|\psi\rangle$

($\hat{U}^\dagger \hat{U} = 1$

(b) When [illegible] measurement the state be[illegible] projected [illegible] projector associated with the meas[illegible] $\hat{P}|\psi\rangle$

Ax5 The probability [illegible] given by the modulus squared of the amplitude [illegible] in front of the state after projection

prob $= (\langle\psi|\hat{P})(\hat{P}|\psi\rangle) = \langle\psi|\hat{P}|\psi\rangle$

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$|\psi\rangle \in \mathcal{H}$

4 Evolution

(a) When no measurement is made the state evolves unitarily $|\psi\rangle \rightarrow \hat{U}|\psi\rangle$

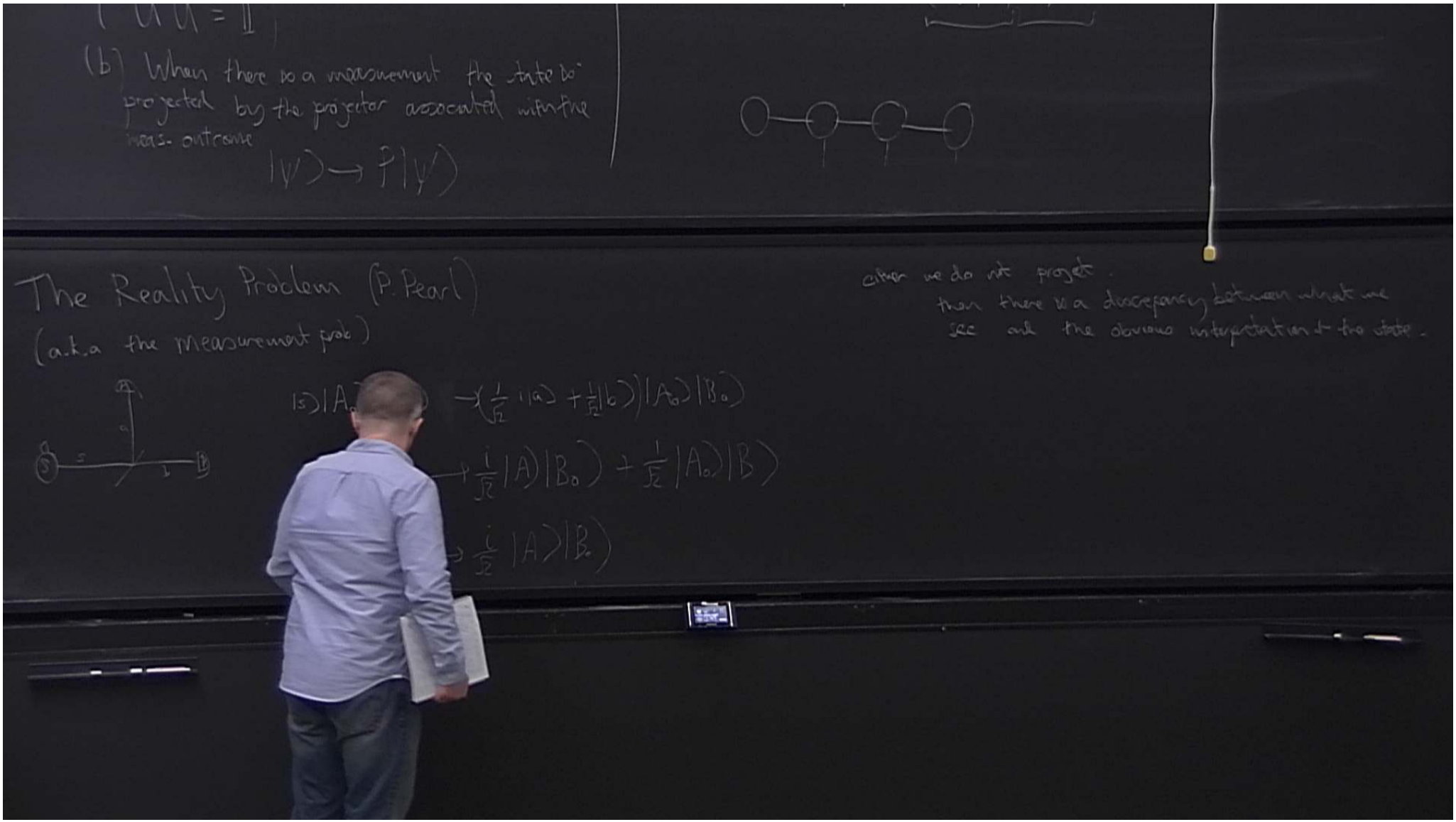
$(\hat{U}^\dagger \hat{U} = \mathbb{1})$

(b) When there is a measurement the state is projected by the projector associated with the outcome

$|\psi\rangle \rightarrow \hat{P}|\psi\rangle$

Ax 5 The probability is given by the modulus squared of the amplitude in front of the state after projection

$\text{prob} = (\langle\psi|P)(P|\psi\rangle) = \langle\psi|P|\psi\rangle$


(b) When there is a measurement the state is projected by the projector associated with the meas. outcome
$|\psi\rangle \to P|\psi\rangle$
The Reality Problem (P. Pearl)
(a.k.a the measurement prob)
either we do not project.
then there is a discrepancy between what we see and the obvious interpretation of the state.

$\sum_i \Pi_i = \mathbb{I}$

(b) When there is a measurement the state is projected by the projector associated with the meas. outcome

$|\psi\rangle \rightarrow \hat{P}_i|\psi\rangle$

The Reality Problem (P. Pearl)

(a.k.a the measurement problem)

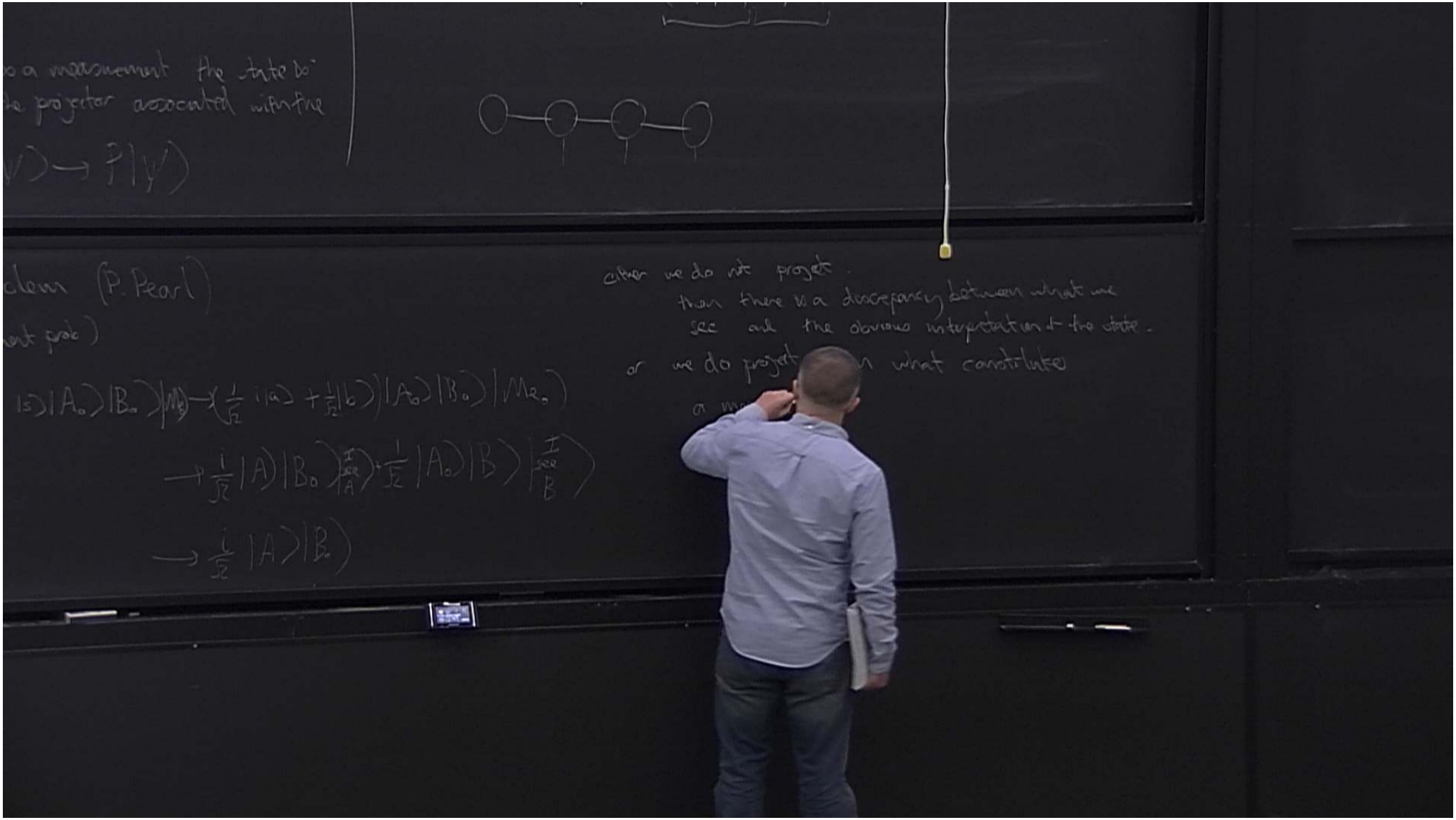
either we do not project then there is a discrepancy between what we see and the obvious interpretation of the state.

or

$|S\rangle = |A_0\rangle|B_0\rangle|M_0\rangle \rightarrow \left(\frac{1}{\sqrt{2}}|a\rangle + \frac{1}{\sqrt{2}}|b\rangle\right)|A_0\rangle|B_0\rangle|M_{2_0}\rangle$

$\rightarrow \frac{1}{\sqrt{2}}|A\rangle|B_0\rangle|\text{see } A\rangle + \frac{1}{\sqrt{2}}|A_0\rangle|B\rangle|\text{see } B\rangle$

$\rightarrow \frac{i}{\sqrt{2}}|A\rangle|B_0\rangle$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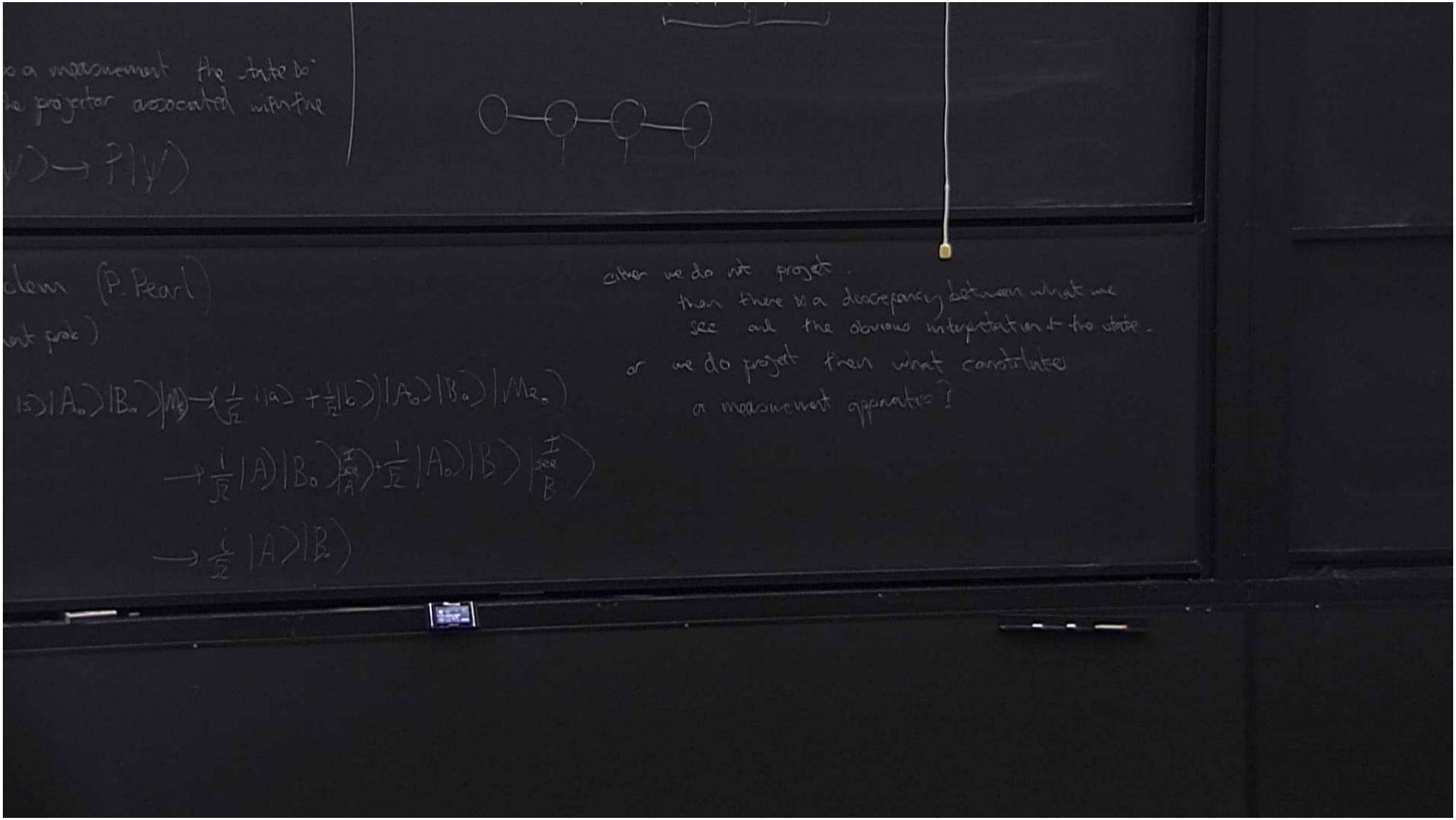
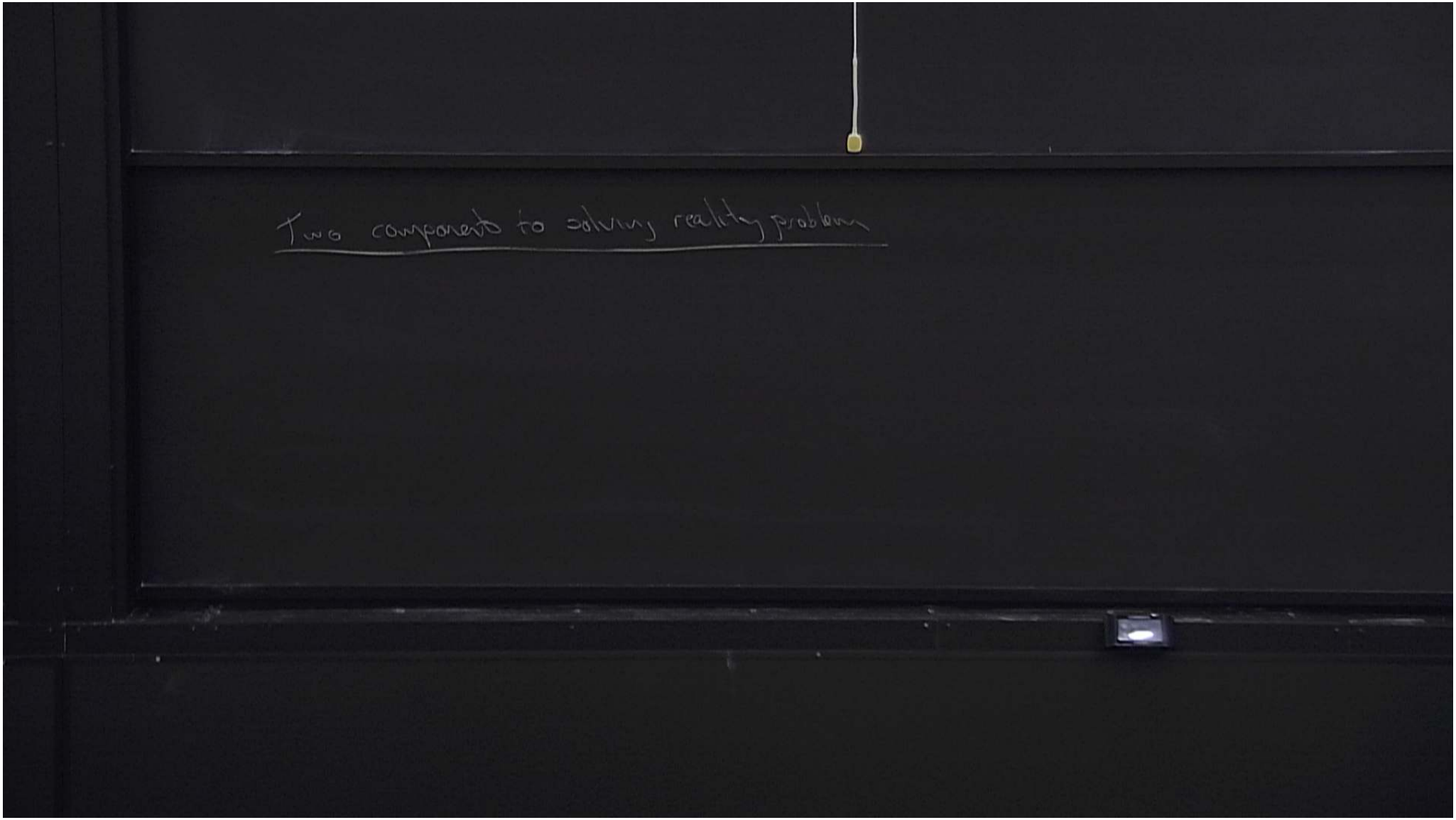
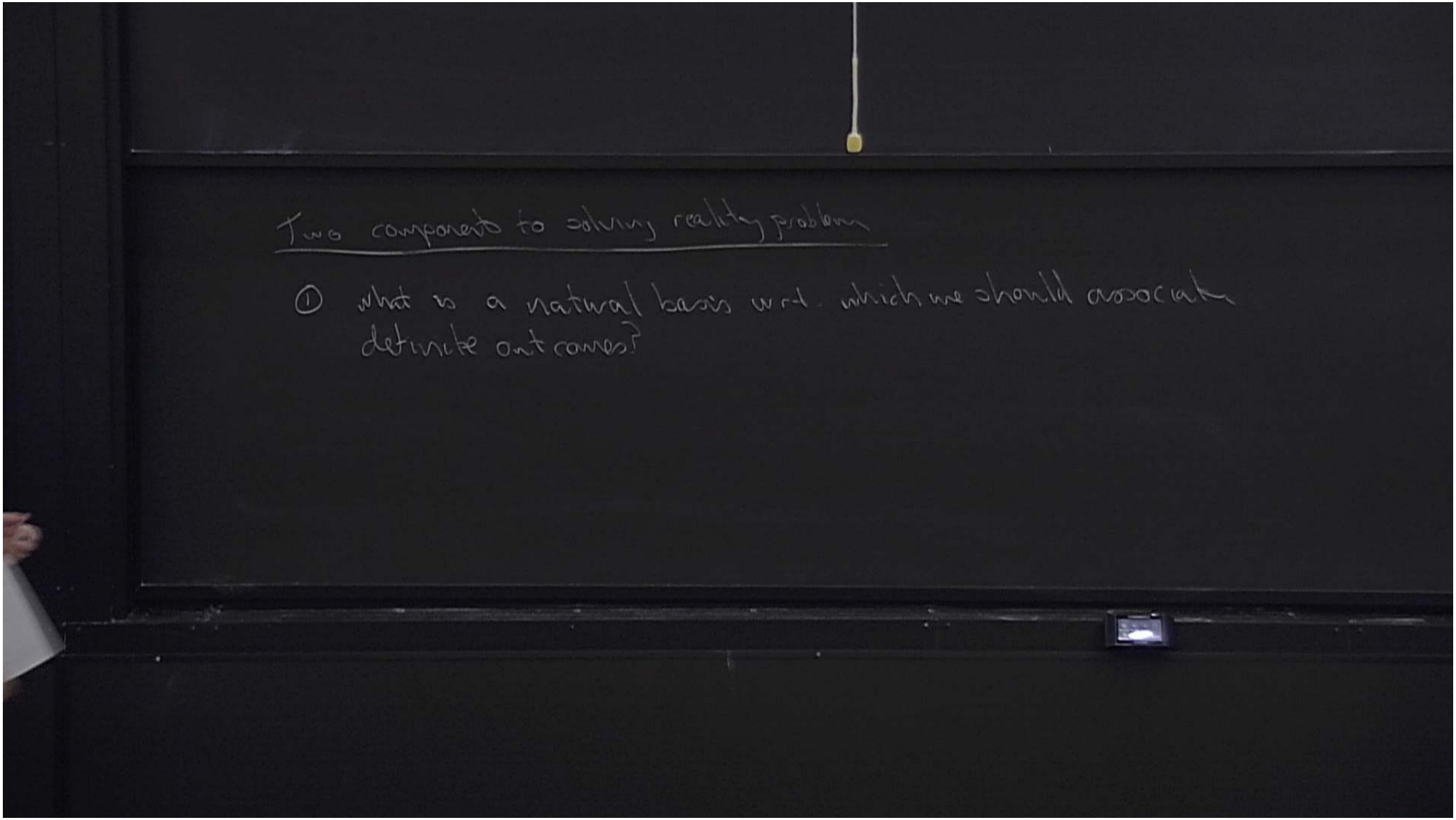

a measurement the state is
projector associated with the
$|\psi\rangle \to P|\psi\rangle$
(P. Pearl)
either we do not project.
then there is a discrepancy between what we
see and the obvious interpretation of the state.
or we do project then what constitutes
a measurement apparatus?


Two components to solving reality problems


Two components to solving reality problems
① what is a natural basis w.r.t. which we should associate definite outcomes?

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An answer is provided by decoherence.

Two components to solving reality problem

① what is a natural basis w.r.t. which we should associate definite outcomes? $\frac{1}{\sqrt{2}}\left(|\text{I see}_A\rangle \pm |\text{I see}_B\rangle\right)$

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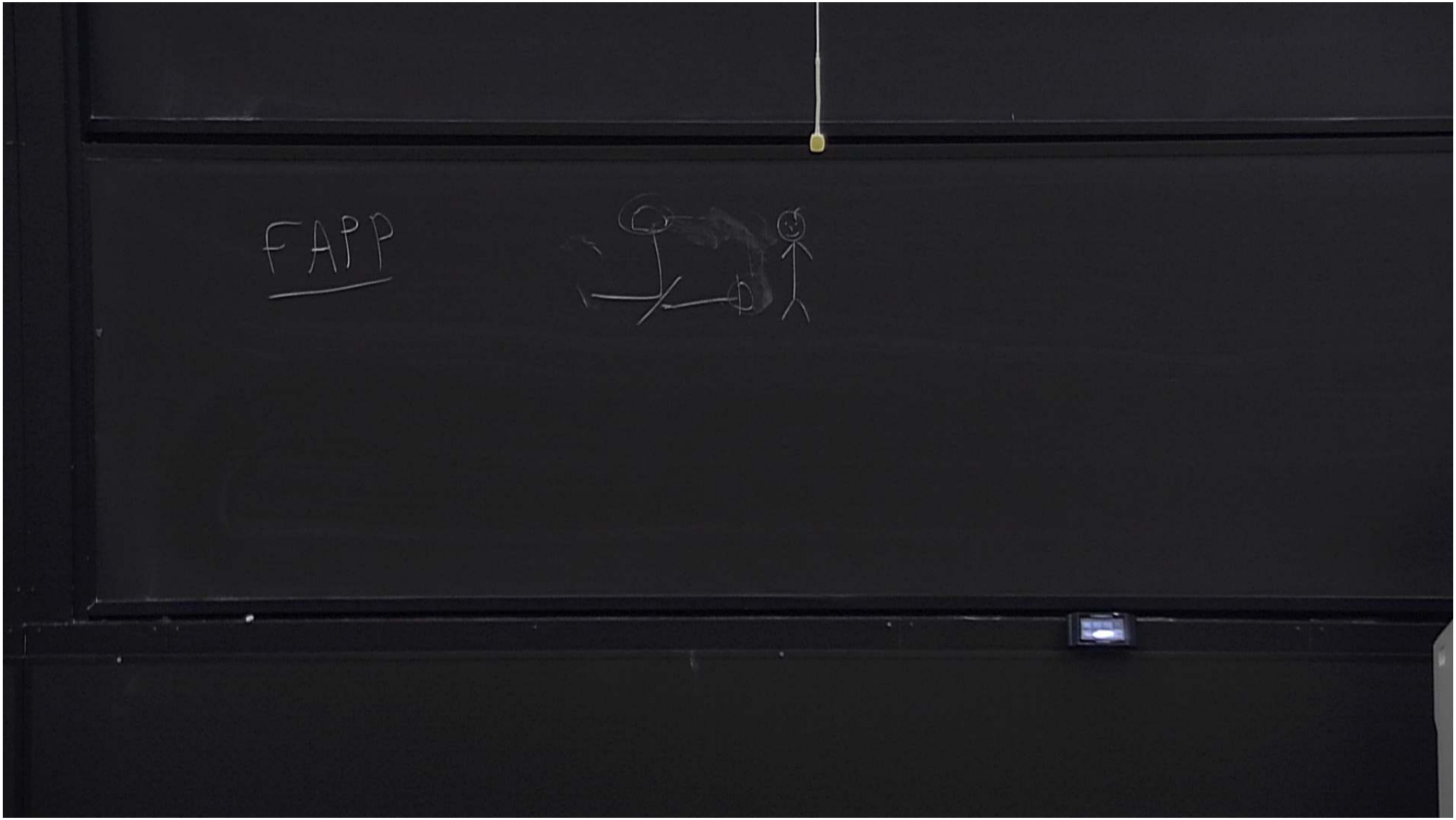
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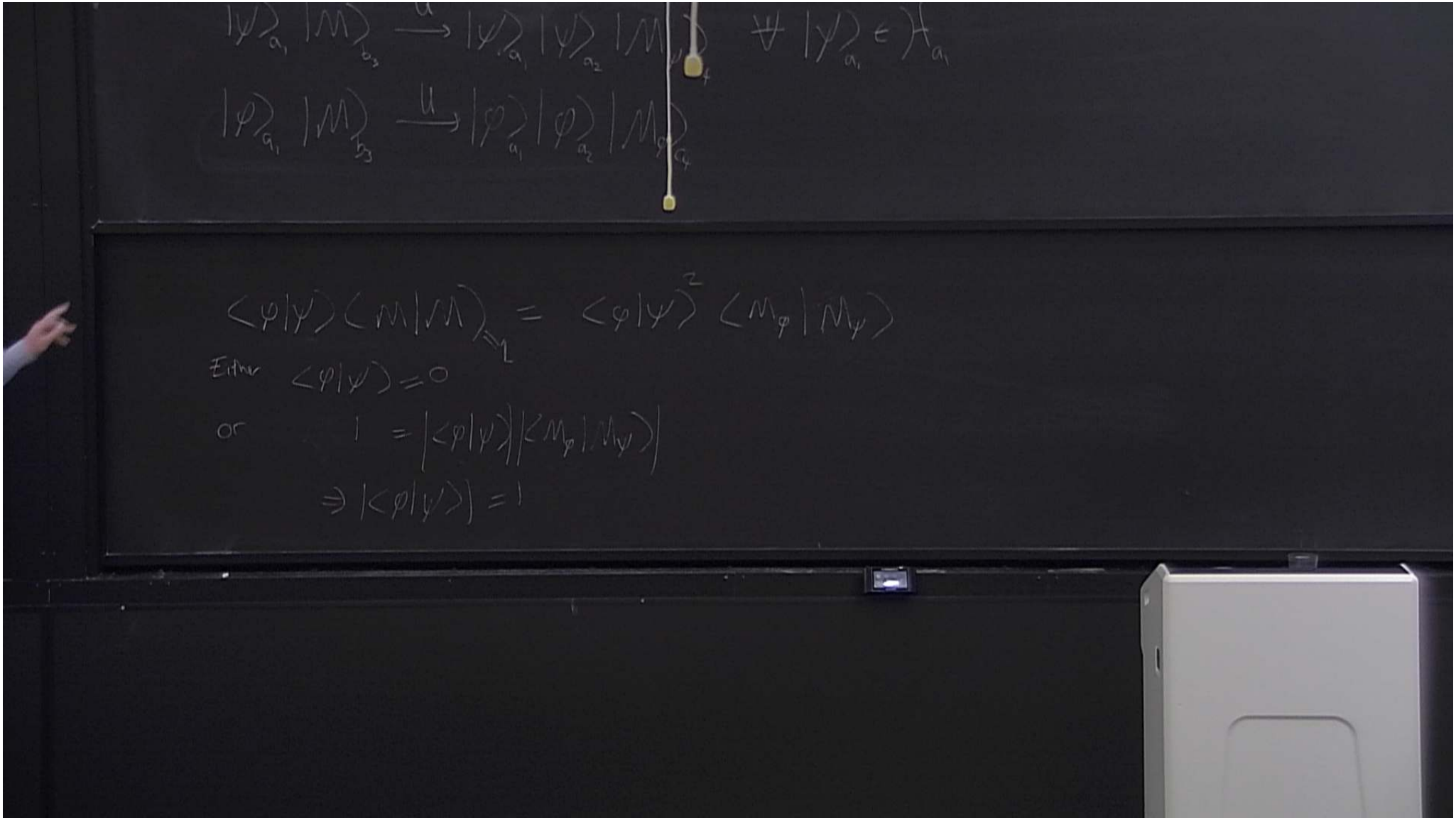
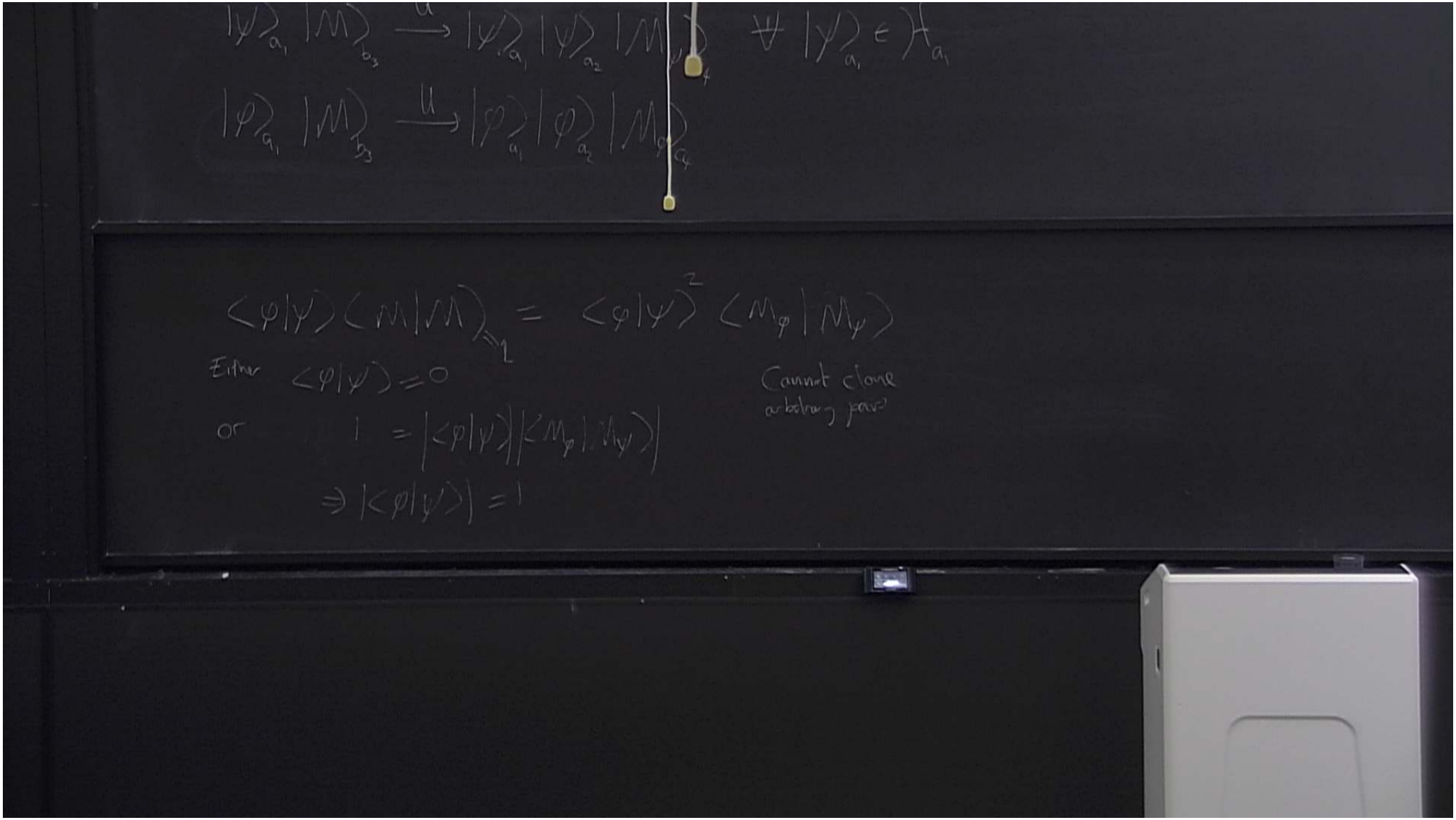

$|\psi\rangle_{a_1}|M\rangle_{b_3} \xrightarrow{U} |\psi\rangle_{a_1}|\psi\rangle_{a_2}|M_\psi\rangle_{c_4} \quad \forall\, |\psi\rangle_{a_1} \in \mathcal{H}_{a_1}$
$|\varphi\rangle_{a_1}|M\rangle_{b_3} \xrightarrow{U} |\varphi\rangle_{a_1}|\varphi\rangle_{a_2}|M_\varphi\rangle_{c_4}$
$\langle\varphi|\psi\rangle\langle M|M\rangle = \langle\varphi|\psi\rangle^2 \langle M_\varphi|M_\psi\rangle$
$\langle M|M\rangle = 1$
Either $\langle\varphi|\psi\rangle = 0$
or $1 = |\langle\varphi|\psi\rangle||\langle M_\varphi|M_\psi\rangle|$
$\Rightarrow |\langle\varphi|\psi\rangle| = 1$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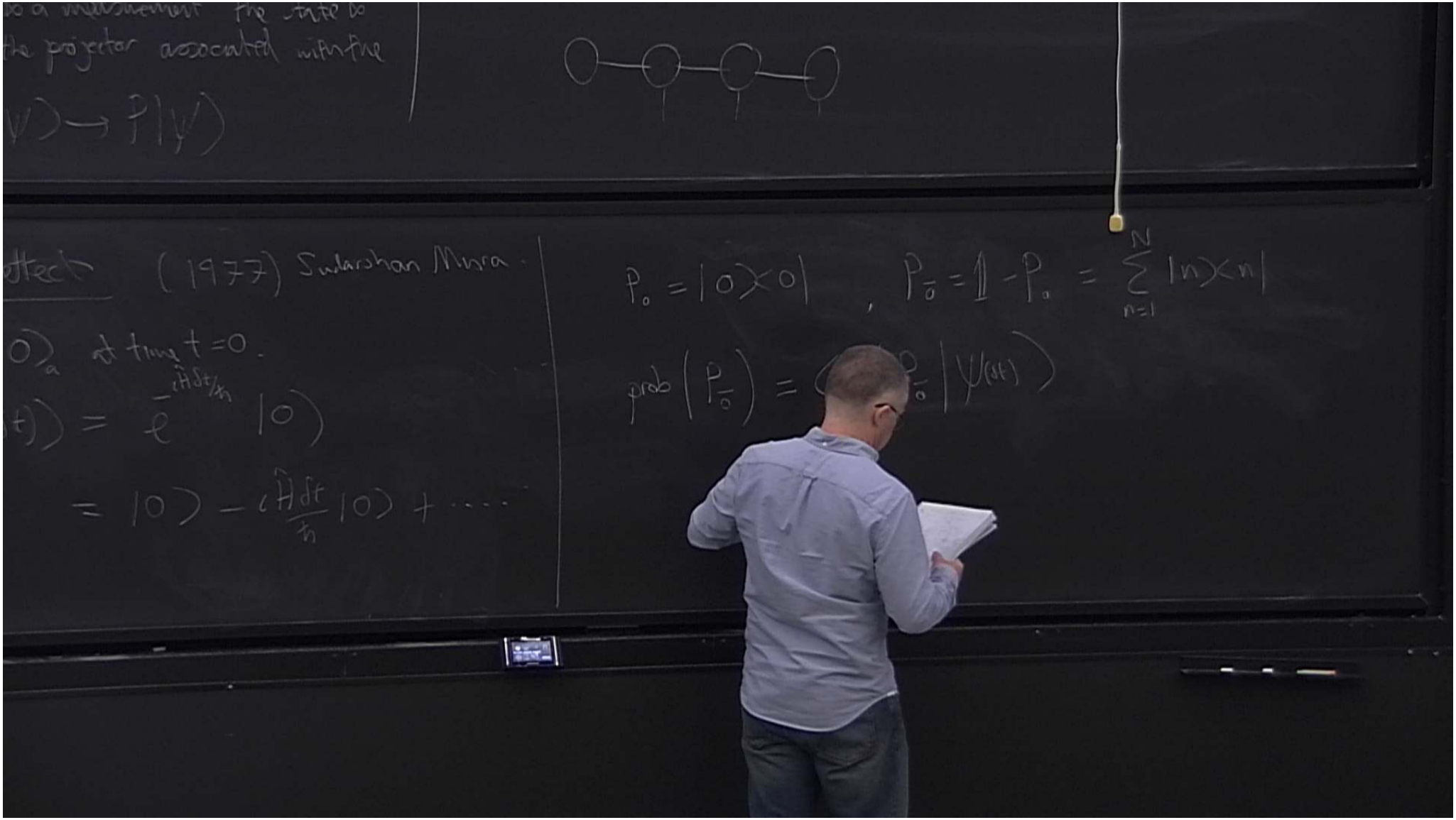
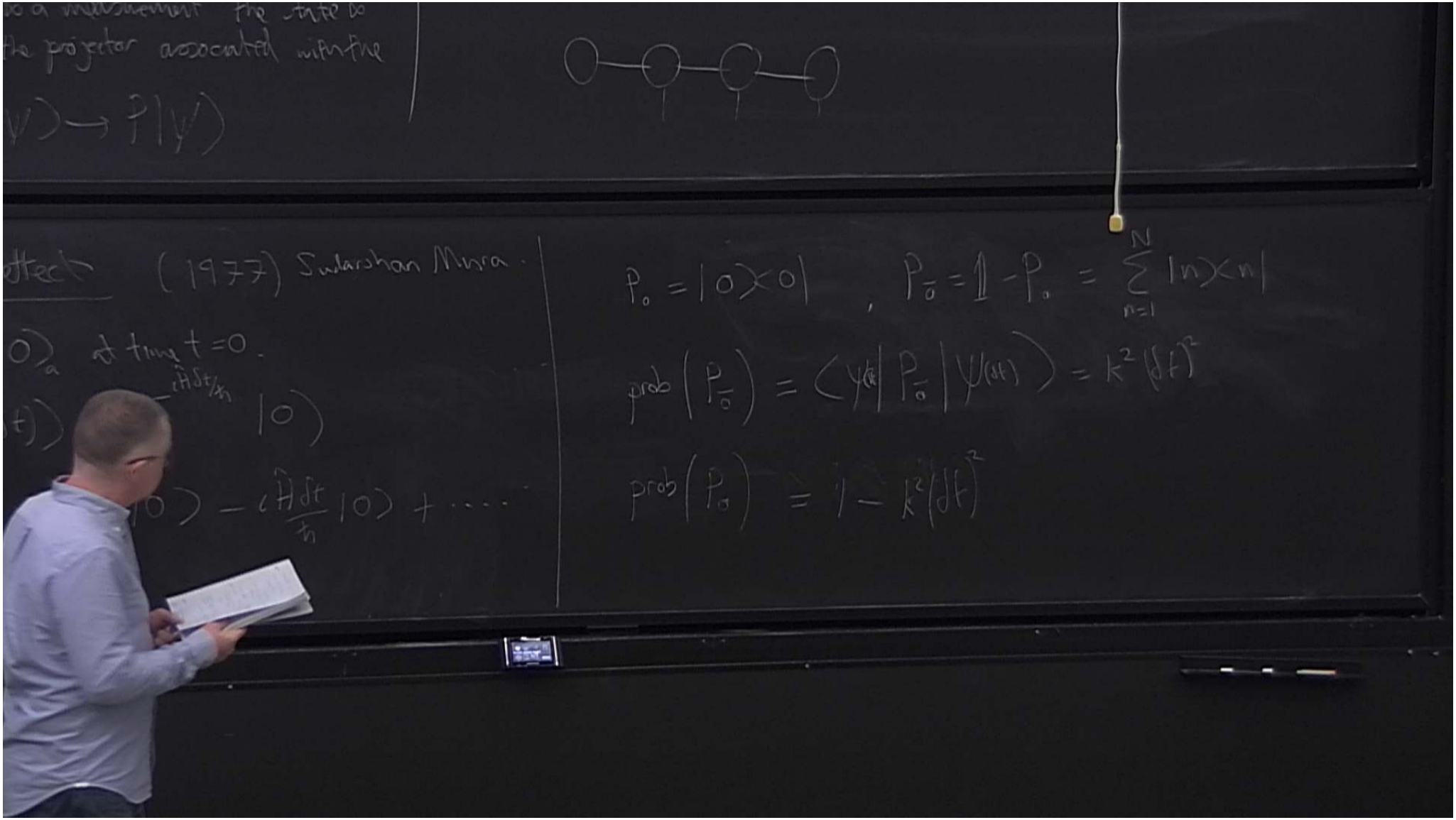
Cannot clone arbitrary pairs


the projector associated with the
(1977) Sudarshan Misra
at time t = 0.
$P_0 = |0\rangle\langle 0|$
$P_{\bar{0}} = \mathbb{1} - P_0 = \sum_{n=1}^{N} |n\rangle\langle n|$
prob $\left(P_{\bar{0}}\right) =$
$= |0\rangle - \frac{i\hat{H}dt}{\hbar}|0\rangle + \cdots$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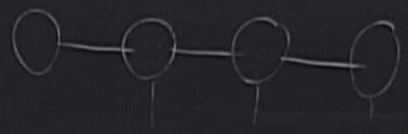
$|0\rangle_a$ at time $t=0$.
$|0\rangle$
$|0\rangle - \frac{i\hat{H}dt}{\hbar}|0\rangle + \cdots$
$P_0 = |0\rangle\langle 0|$, $P_{\bar{0}} = \mathbb{1} - P_0 = \sum_{n=1}^{N} |n\rangle\langle n|$
$\text{prob}\left(P_{\bar{0}}\right) = \langle\psi(dt)|P_{\bar{0}}|\psi(dt)\rangle = k^2(dt)^2$
$\text{prob}\left(P_0\right) = 1 - k^2(dt)^2$

the projector associated with the

$|\psi\rangle \rightarrow P|\psi\rangle$



(1977) Sudarshan Misra

$|0\rangle_a$ at time $t=0$.

$|\psi(t)\rangle = e^{-i\hat{H}\delta t/\hbar}|0\rangle$

$= |0\rangle - i\frac{\hat{H}\delta t}{\hbar}|0\rangle + \cdots$

$P_0 = |0\rangle\langle 0|$, $P_{\bar{0}} = \mathbb{1} - P_0 = \sum_{n=1}^{N} |n\rangle\langle n|$

$\text{prob}\left(P_{\bar{0}}\right) = \langle\psi(t)|P_{\bar{0}}|\psi(\delta t)\rangle = k^2(\delta t)^2$

$\text{prob}\left(P_0\right) = 1 - k^2(\delta t)^2$