Title: Quantum Foundations Lecture

Speakers: Lucien Hardy

Collection: Quantum Foundations

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The many worlds interpretation (Everett 1957)

The axioms

1. The ontology at time t is given by the wavefunction $|\psi(t)\rangle$
2. The wavefn evolves according to Schrodinger's eqn

$$i\hbar \frac{\partial |\psi\rangle}{\partial t} = \hat{H}|\psi\rangle$$

That's it!!

t 1957)

function $|\psi(t)\rangle$

I will follow David Wallace's approach

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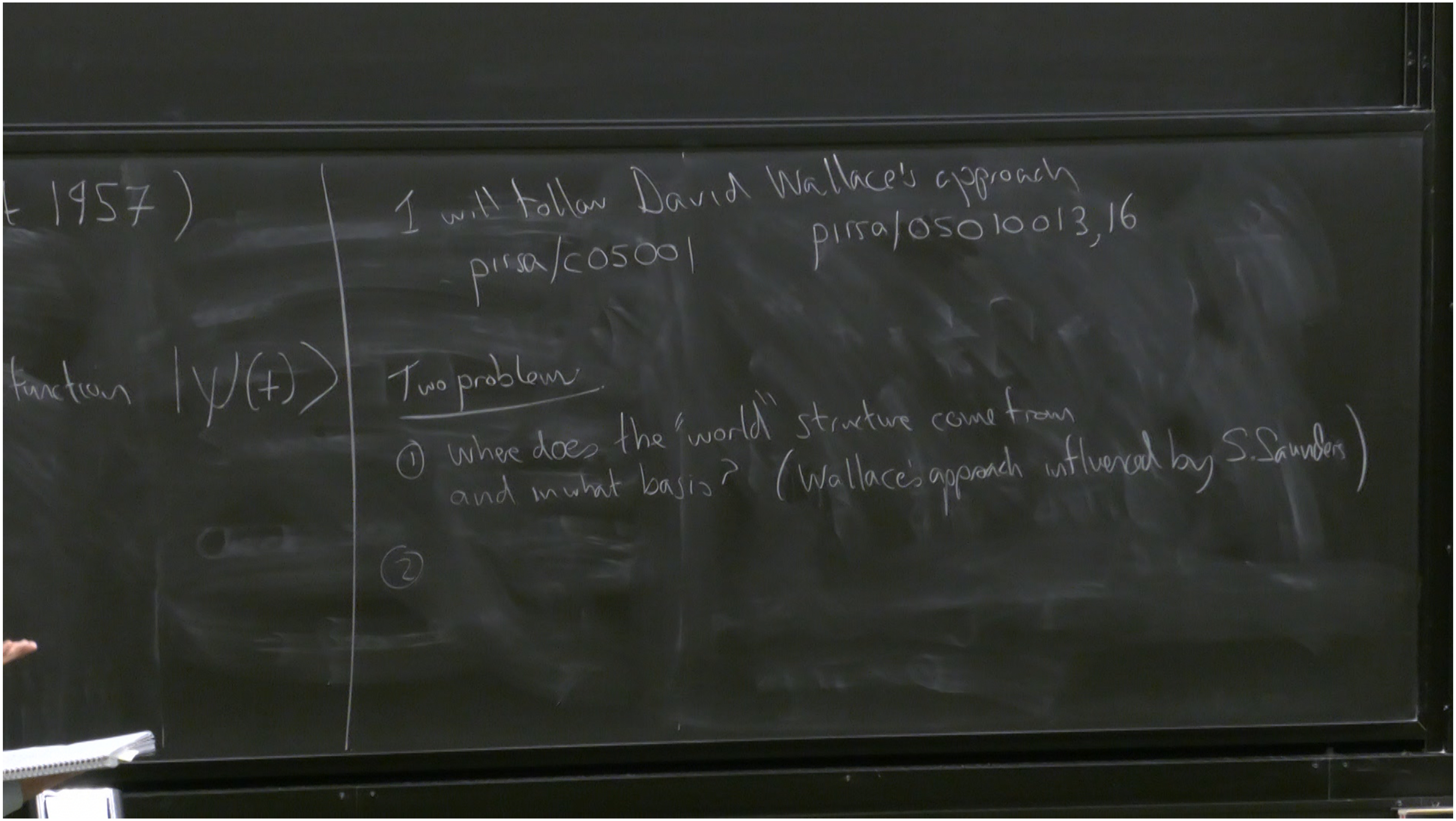
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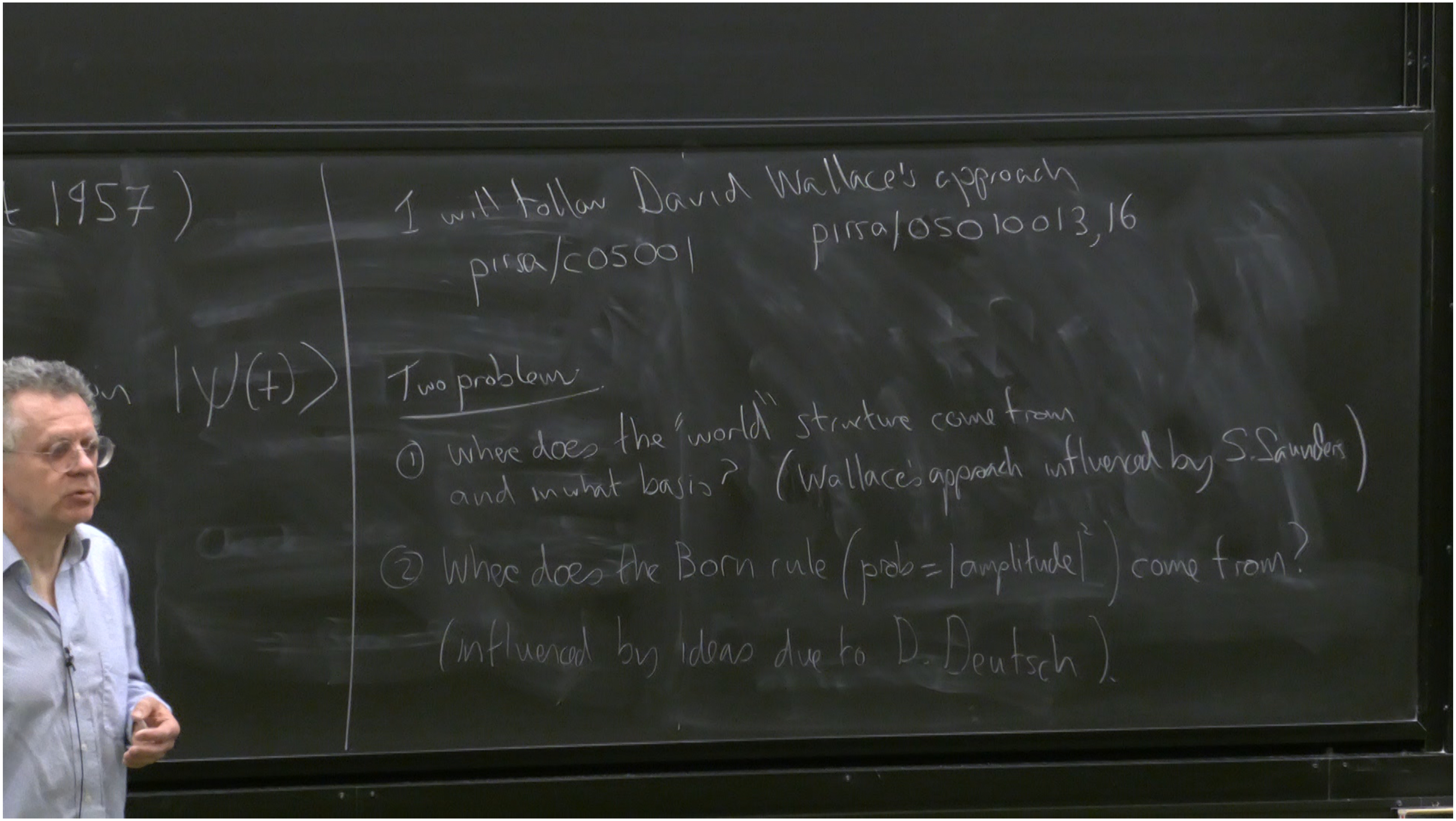
Two problems
1 Where does the "world" structure come from
and in what basis? (Wallace's approach influenced by S. Saunders)
2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Two problems
① Where does the "world" structure come from
and in what basis? (Wallace's approach influenced by S. Saunders)
② Where does the Born rule (prob = |amplitude|²) come from?
(influenced by ideas due to D. Deutsch).

That's it!!

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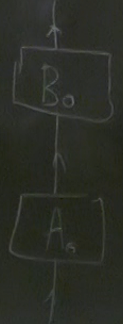
At the fundamental level we just have $|\psi(t)\rangle$ evolving in time.

Wallace uses decoherence to argue that, at the quasiclassical level, have emergence of quasiclassical worlds.



$$|\psi\rangle_S |A_0\rangle_A |B_0\rangle_B \to \alpha|a_1\rangle_S|A_1\rangle|B_0\rangle + \beta|a_2\rangle|A_2\rangle|B_0\rangle$$

$\alpha|a_1\rangle_S + \beta|a_2\rangle_S$

$\gamma|b_1\rangle + \delta|b_2\rangle$

$-\delta^*|b_1\rangle + \gamma^*|b_2\rangle$

$$\to \alpha\gamma|b_1\rangle|A_1\rangle|B_1\rangle + \alpha\delta|b_2\rangle|A_1\rangle|B_2\rangle + \beta(-\delta^*)|b_1\rangle|A_1\rangle|B_1\rangle$$

$= H|\psi\rangle$

When does the Born rule (prob $= |\text{amp}$

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level we just have $|\psi(t)\rangle$ evolving in time.

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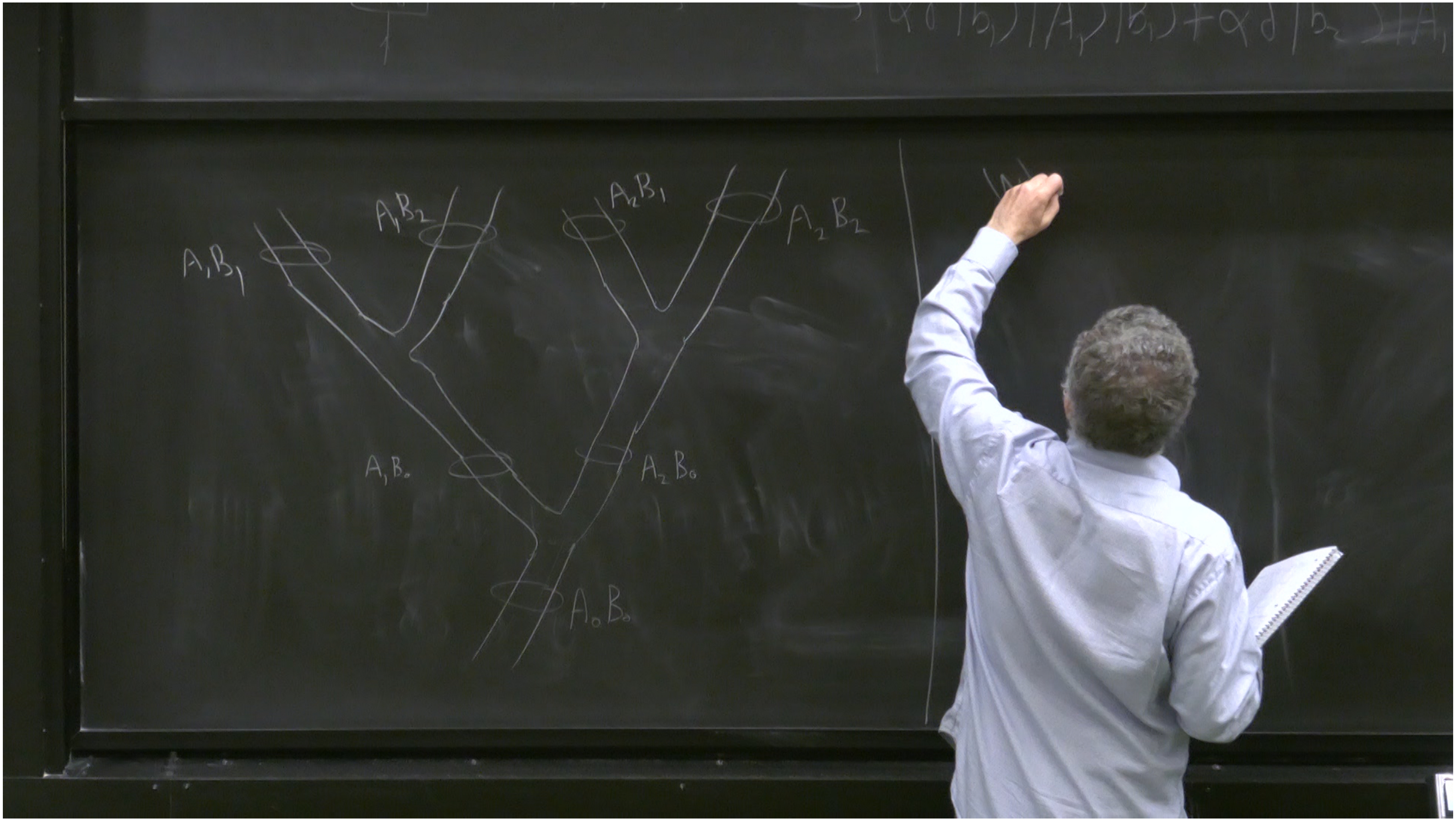
ical worlds.

$$\rangle_B \longrightarrow \alpha \underbrace{|a_1\rangle_S}_{\gamma|b_1\rangle + \delta|b_2\rangle} |A_1\rangle|B_0\rangle + \beta \underbrace{|a_2\rangle}_{-\delta^*|b_1\rangle + \gamma^*|b_2\rangle} |A_2\rangle|B_0\rangle$$

$$\longrightarrow \alpha\gamma|b_1\rangle|A_1\rangle|B_1\rangle + \alpha\delta|b_2\rangle|A_1\rangle|B_2\rangle + \beta(-\delta^*)|b_1\rangle|A_2\rangle|B_1\rangle + \beta\gamma^*|b_2\rangle|A_2\rangle|B_2\rangle$$


A_1B_1
A_1B_2
A_2B_1
A_2B_2
A_1B_0
A_2B_0
A_0B_0

What picks out the basis for this branching?

could, instead, have had $\dfrac{\left(|A_1\rangle \pm |A_2\rangle\right)}{\sqrt{2}} = |A_\pm\rangle$

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could, instead, have had $\frac{(|A_1\rangle \pm |A_2\rangle)}{\sqrt{2}} = |A_\pm\rangle$

Invoke environmental degrees of freedom.

$$)+\delta|b_2) \qquad -\delta^*|b_1)+\gamma^*|b_2)$$

$$b_1)|A_1)|B_1)+\alpha\delta|b_2)|A_1)|B_2)+\beta(-\delta^*)|b_1)|A_2)|B_1)+\beta\gamma^*|b_2)|A_2)|B_2)$$

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$\ldots + \delta|b_2\rangle$ $\qquad -\delta^*|b_1\rangle + \gamma^*|b_2\rangle$

$\ldots |b_1\rangle|A_1\rangle|B_1\rangle + \alpha\delta|b_2\rangle|A_1\rangle|B_2\rangle + \beta(-\delta^*)|b_1\rangle|A_2\rangle|B_1\rangle + \beta\gamma^*|b_2\rangle|A_2\rangle|B_2\rangle$

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where $\langle E_1|E_2\rangle \simeq 0$

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persistence/stability of this supports the branching structure

where $\langle E_1|E_2\rangle \simeq 0$

$\ldots)|A_1\rangle|B_2\rangle + \beta(-\delta^*)|b_1\rangle|A_2\rangle|B_1\rangle + \beta\gamma^*|b_2\rangle|A_2\rangle|B_2\rangle$

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$|A_\pm\rangle$

\ degrees of freedom

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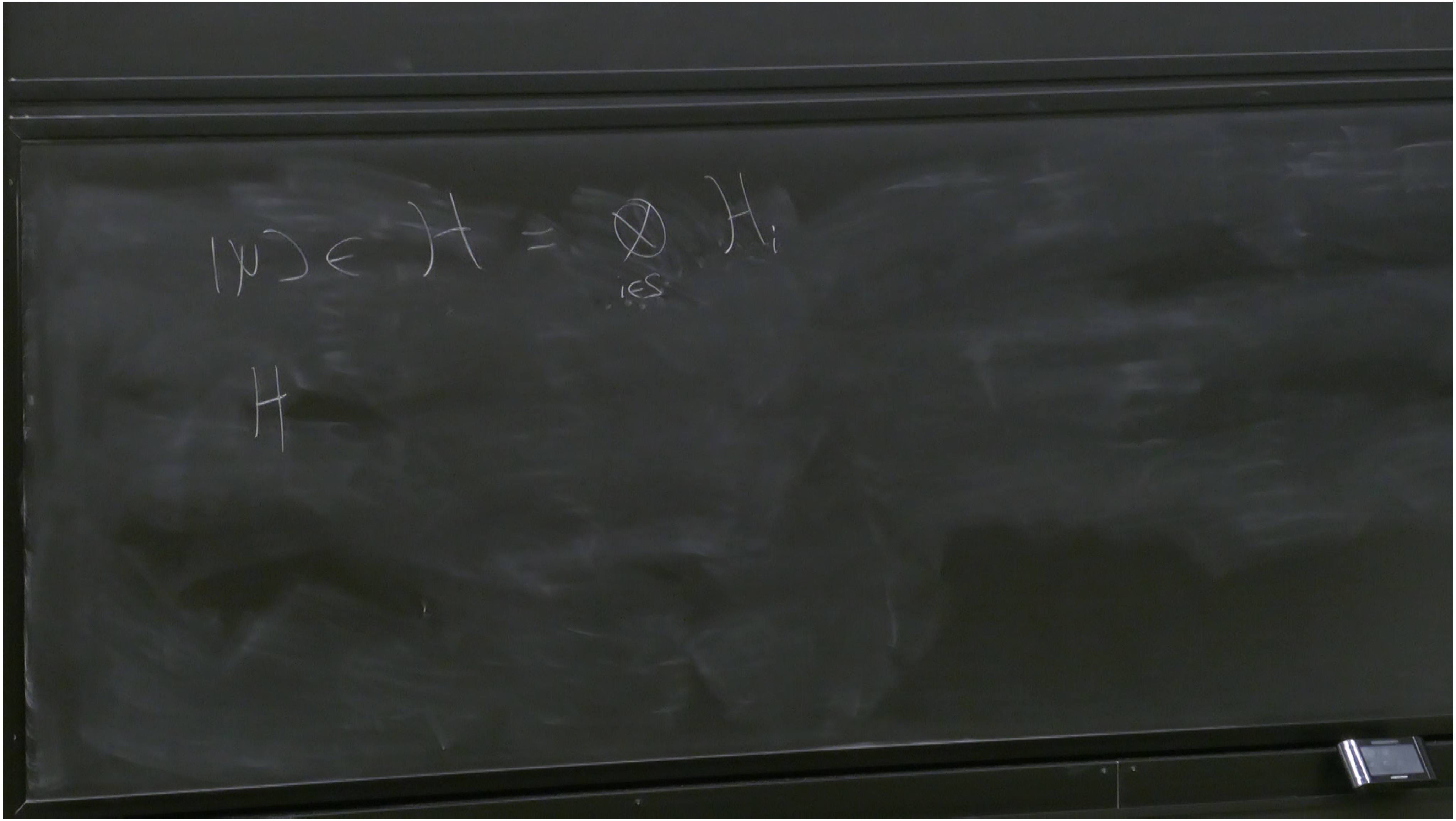
POVM's

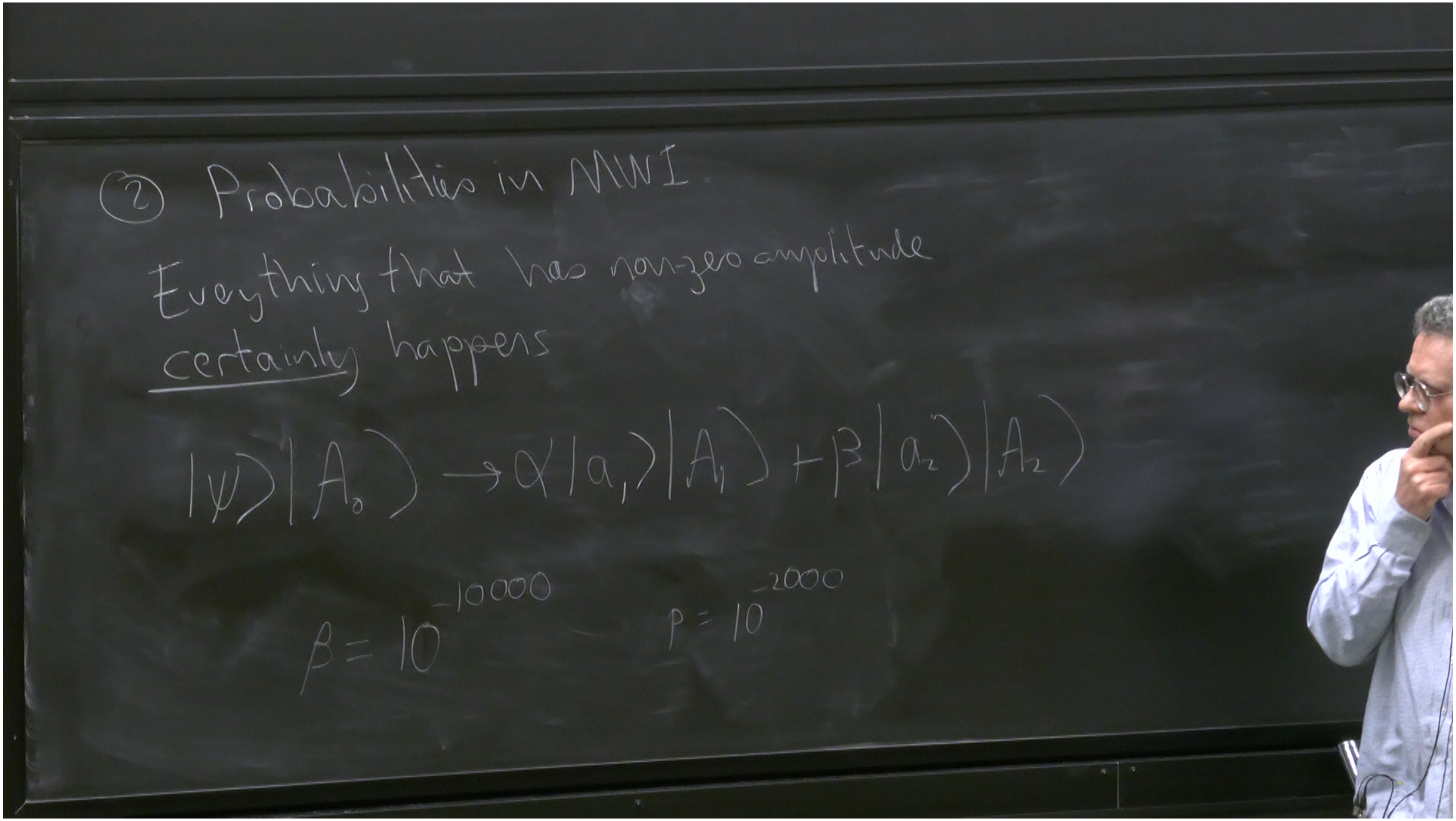

$|\psi\rangle \in \mathcal{H} = \bigotimes_{i \in S} \mathcal{H}_i$
H

(2) Probabilities in MWI

Everything that has non-zero amplitude
<u>certainly</u> happens

$$|\psi\rangle|A_0\rangle \to \alpha|a_1\rangle|A_1\rangle + \beta|a_2\rangle|A_2\rangle$$

$$\beta = 10^{-10000}$$


② Probabilities in MWI
Everything that has non-zero amplitude
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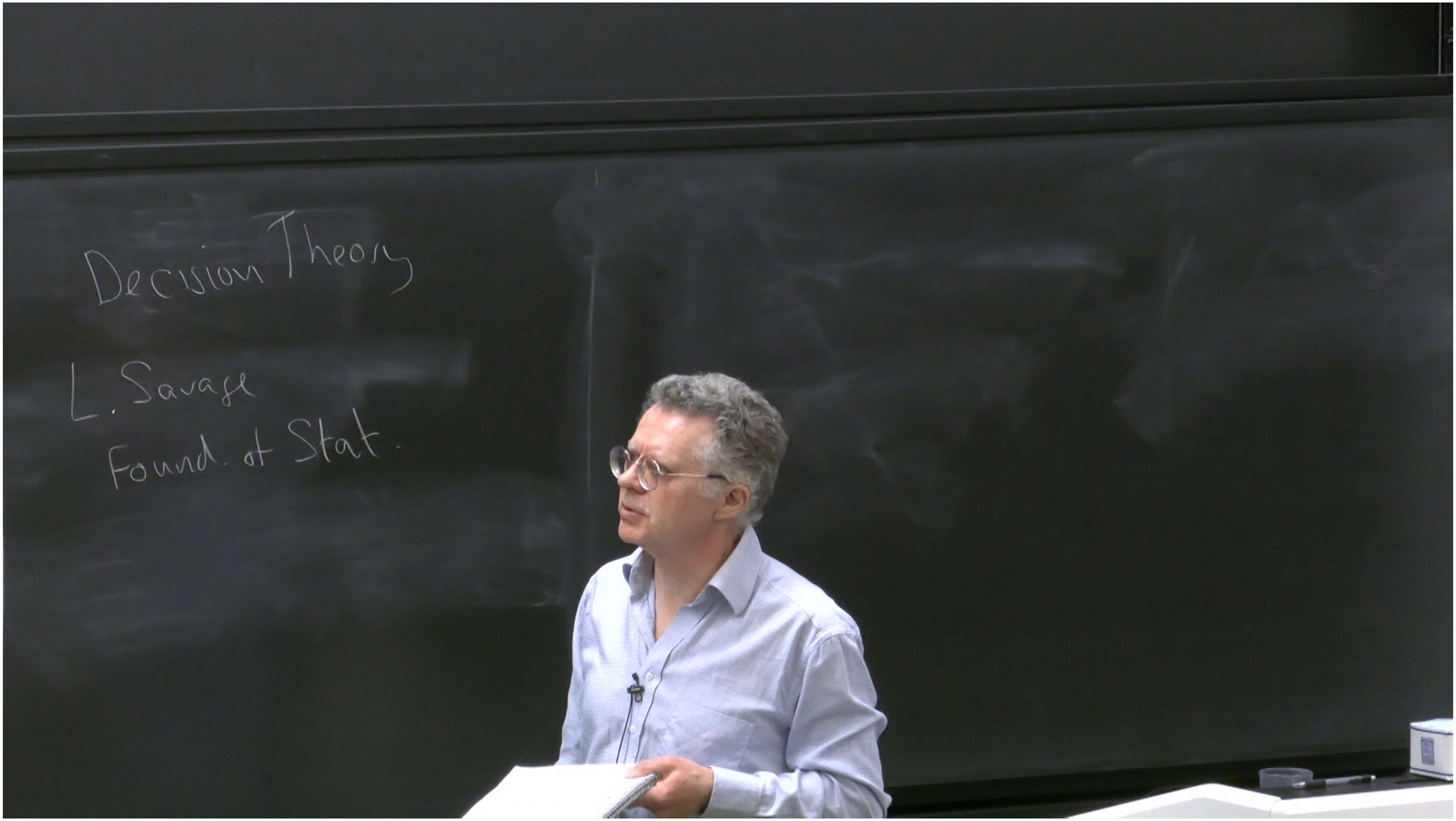
$|\psi\rangle|A_0\rangle \to \alpha|a_1\rangle|A_1\rangle + \beta|a_2\rangle|A_2\rangle$
$\beta = 10^{-10000}$
$p = 10^{-2000}$


Decision Theory
L. Savage
Found. of Stat.