Title: Quantum Foundations Lecture

Speakers: Lucien Hardy

Collection: Quantum Foundations

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The many worlds interpretation (Everett 1957)

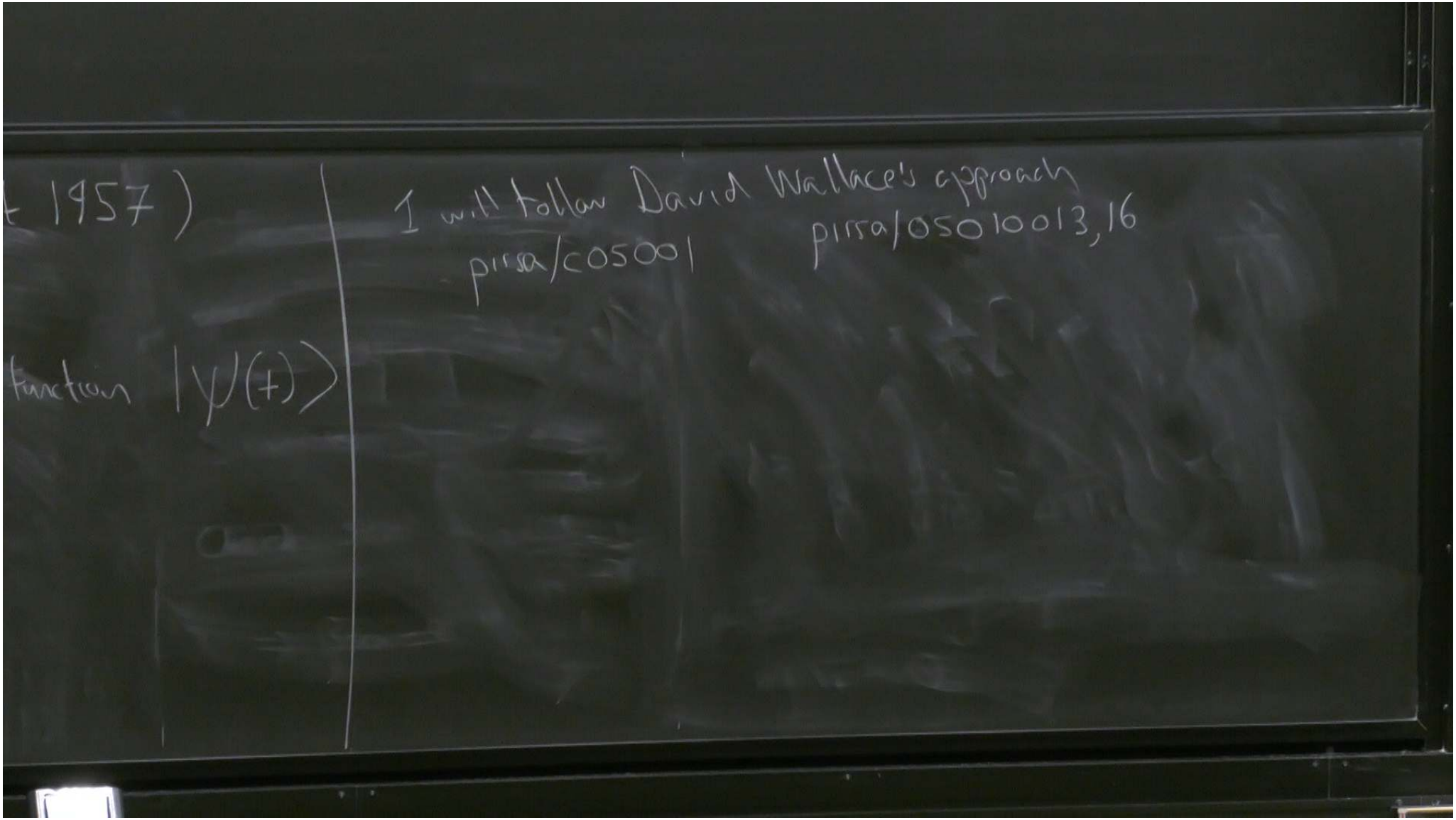
The axioms

① The ontology at time t is given by the wavefunction $|\psi(t)\rangle$

② The wavefn evolves according to Schrodinger's eqn

$$i\hbar \frac{d|\psi\rangle}{dt} = \hat{H}|\psi\rangle$$

That's it!!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function |ψ(t)⟩
I will follow David Wallace's approach
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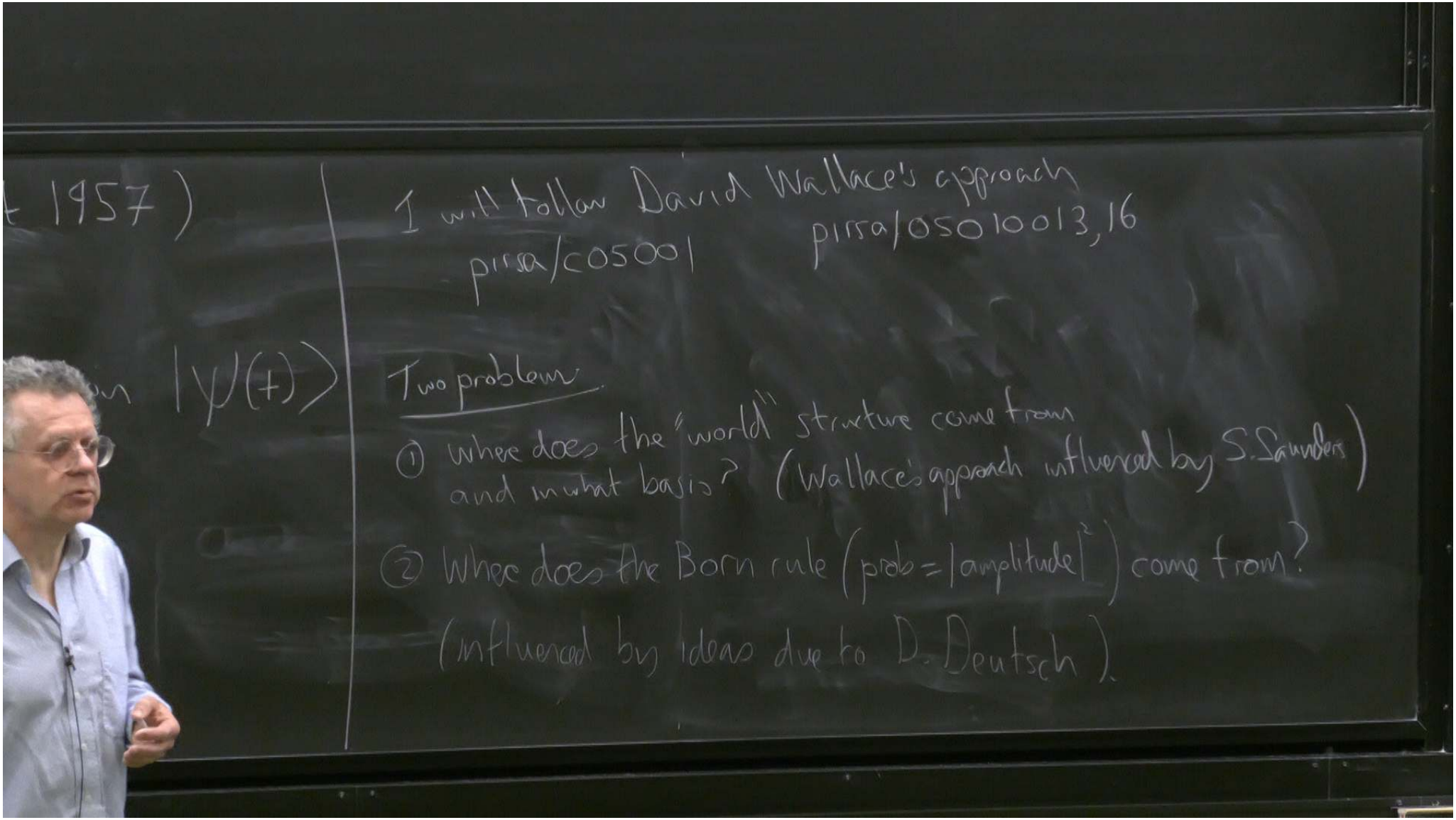
Two problems

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!!

(influe

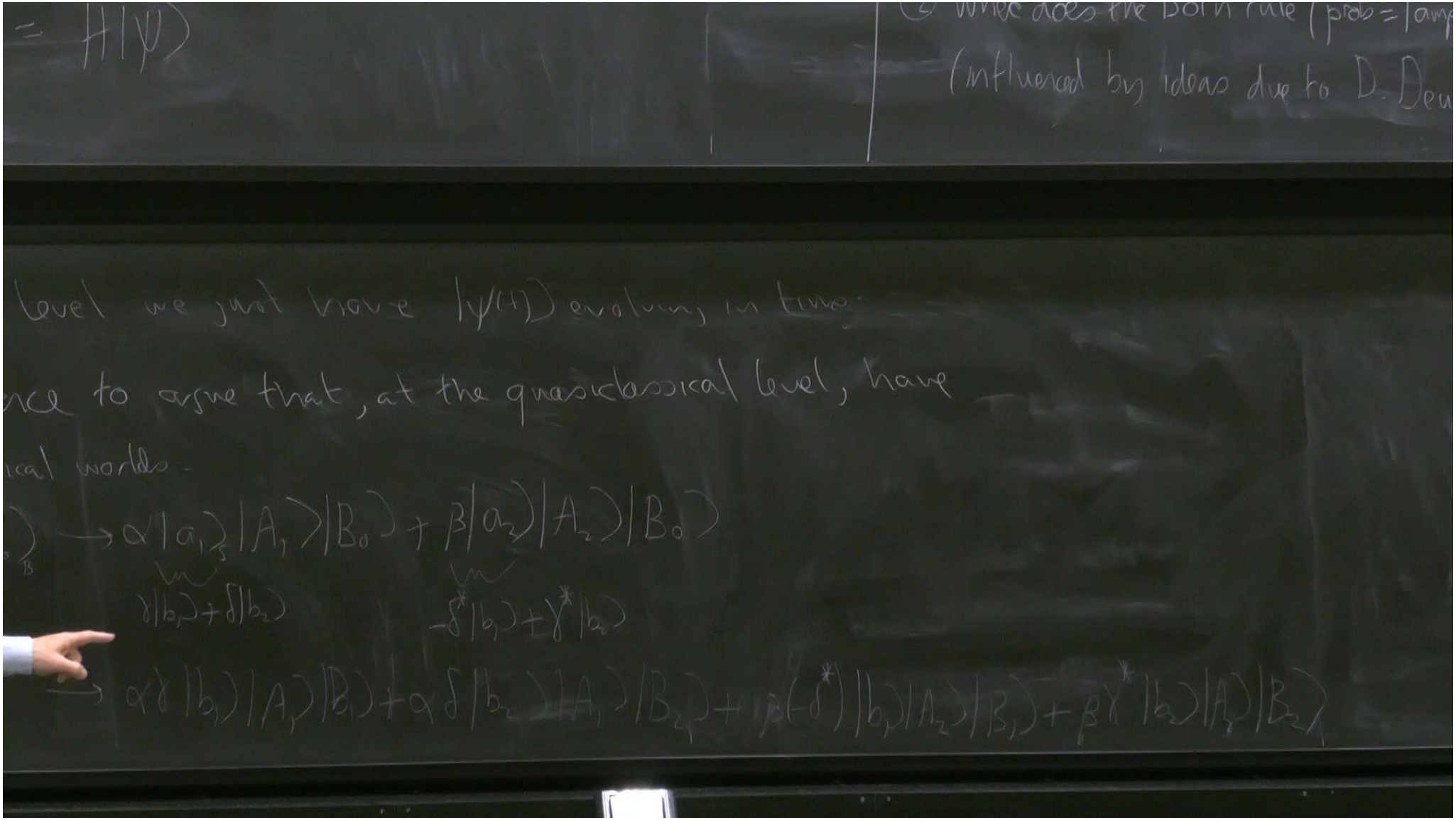
At the fundamental level we just have $|\psi(t)\rangle$ evolving in time.

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

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

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

$\alpha|a_1\rangle_S + \beta|a_2\rangle_S \rightarrow \alpha\gamma|b_1\rangle|A_1\rangle|B_1\rangle + \alpha\delta|b_2\rangle|A_1\rangle|B_2\rangle + \beta(-\delta^*)|b_1\rangle|A_2\rangle|B_1\rangle$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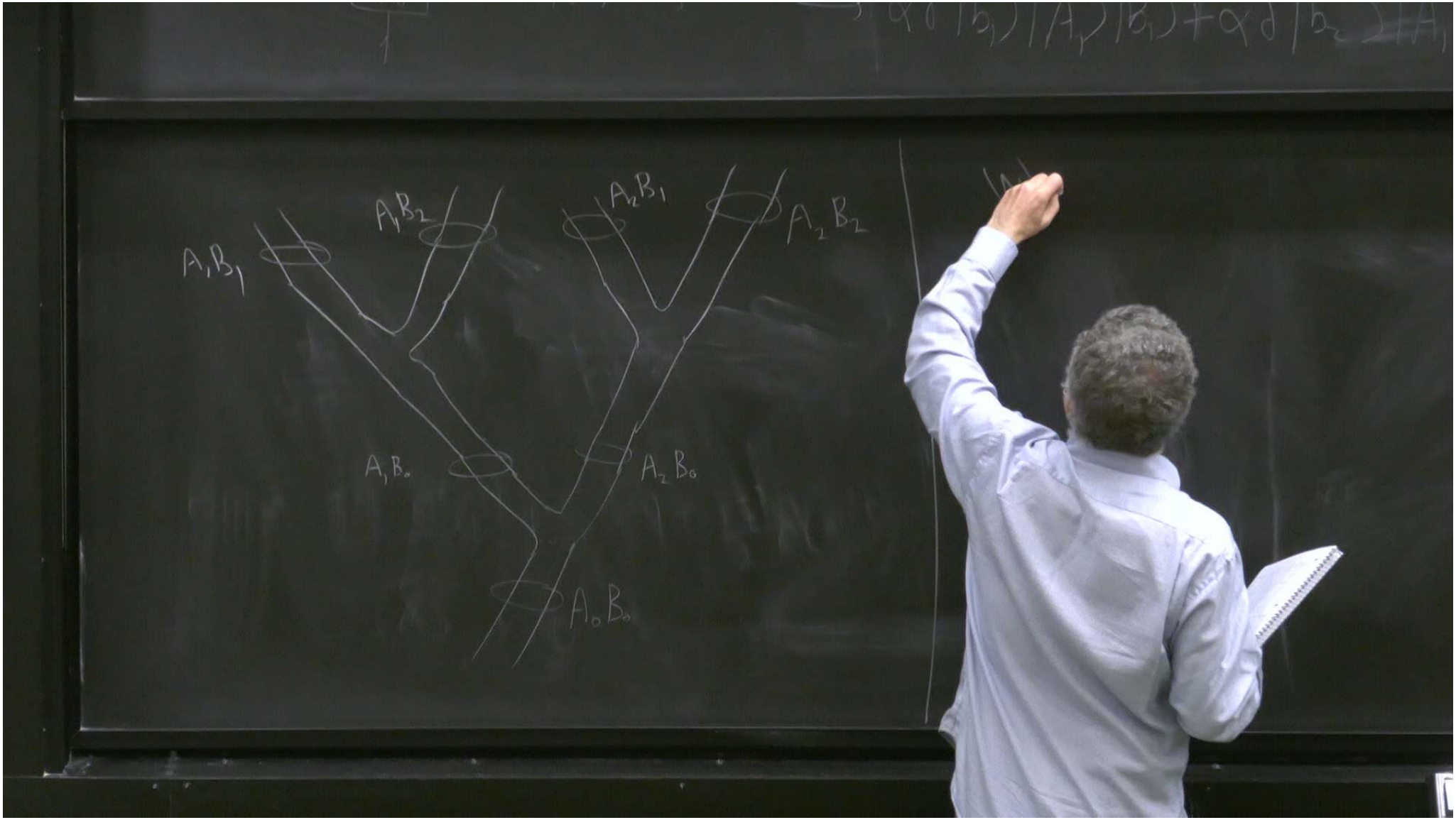
A1B2
A2B1
A2B2
A1B1
A1B0
A2B0
A0B0

What picks out the basis for this branching?

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

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Invoke environmental degrees of freedom

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

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

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$|a_i\rangle|A_0\rangle|E_0\rangle \xrightarrow{\text{measurement}} |a_i\rangle|A_i\rangle|E_0\rangle \xrightarrow[\text{with environment.}]{\text{interaction}} |a_i\rangle|A_i\rangle|E_i\rangle \quad i=1,2.$

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

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persistance/stability of this supports the branching structure

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

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

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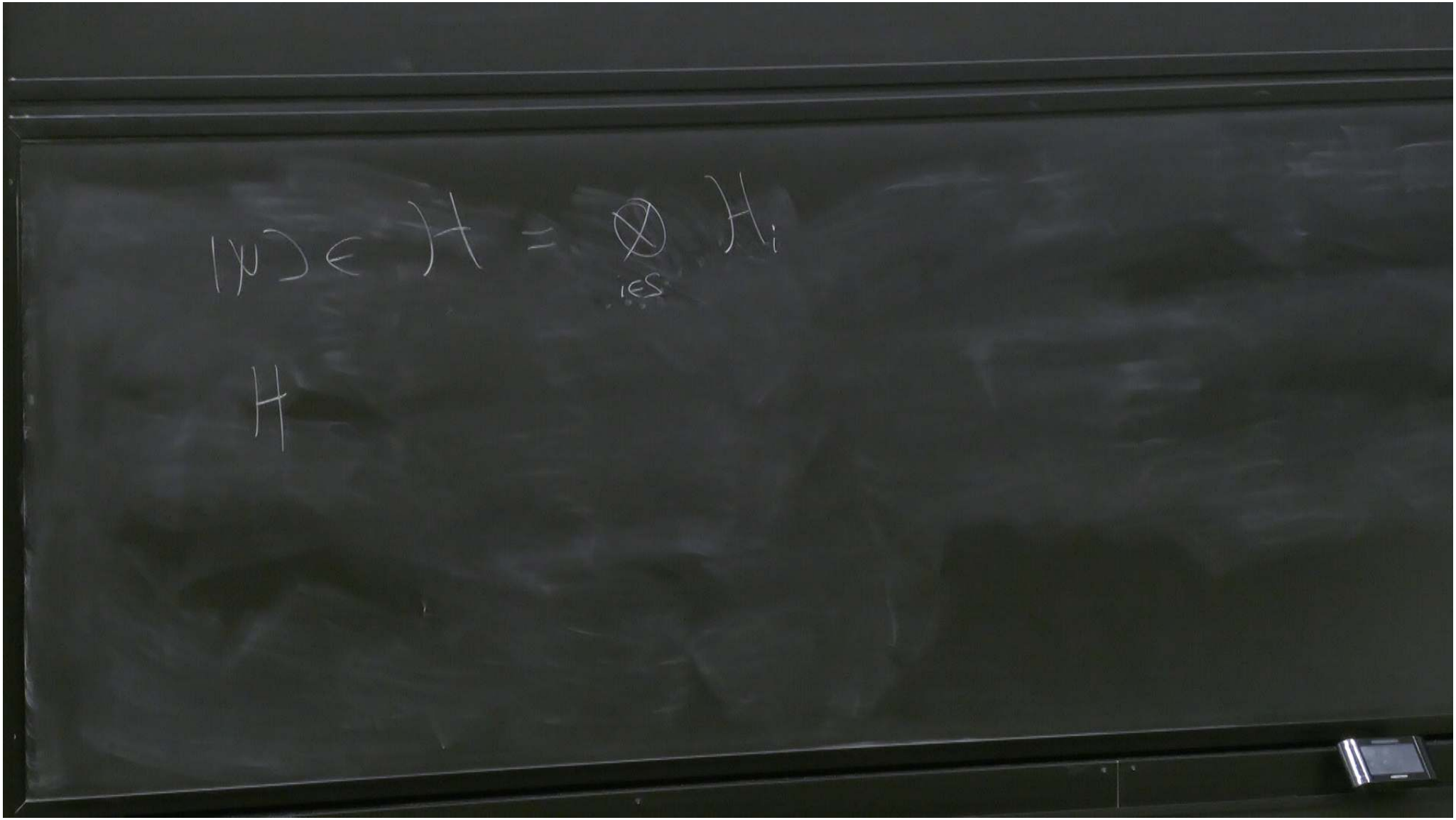
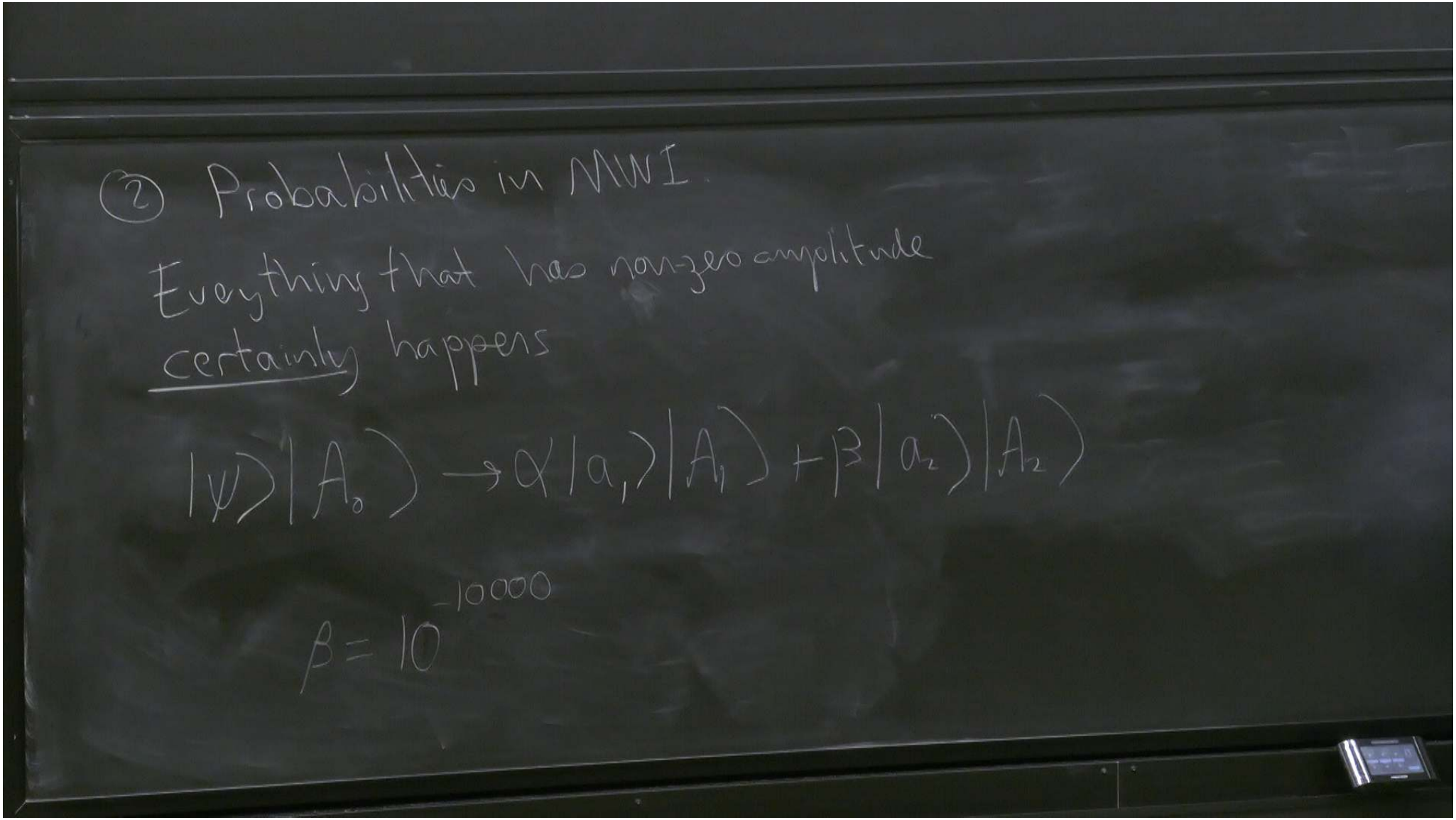
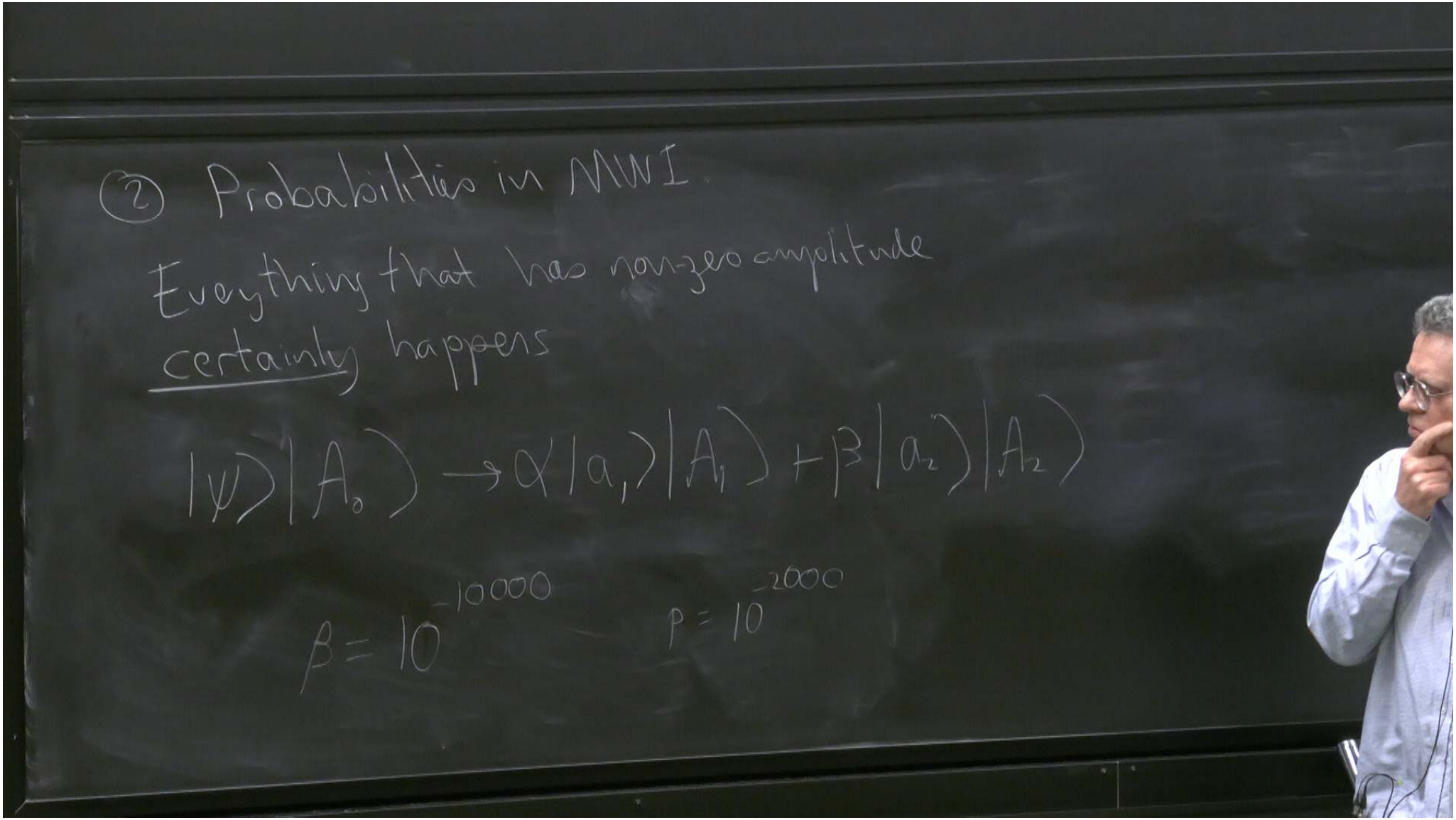
POVM's


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


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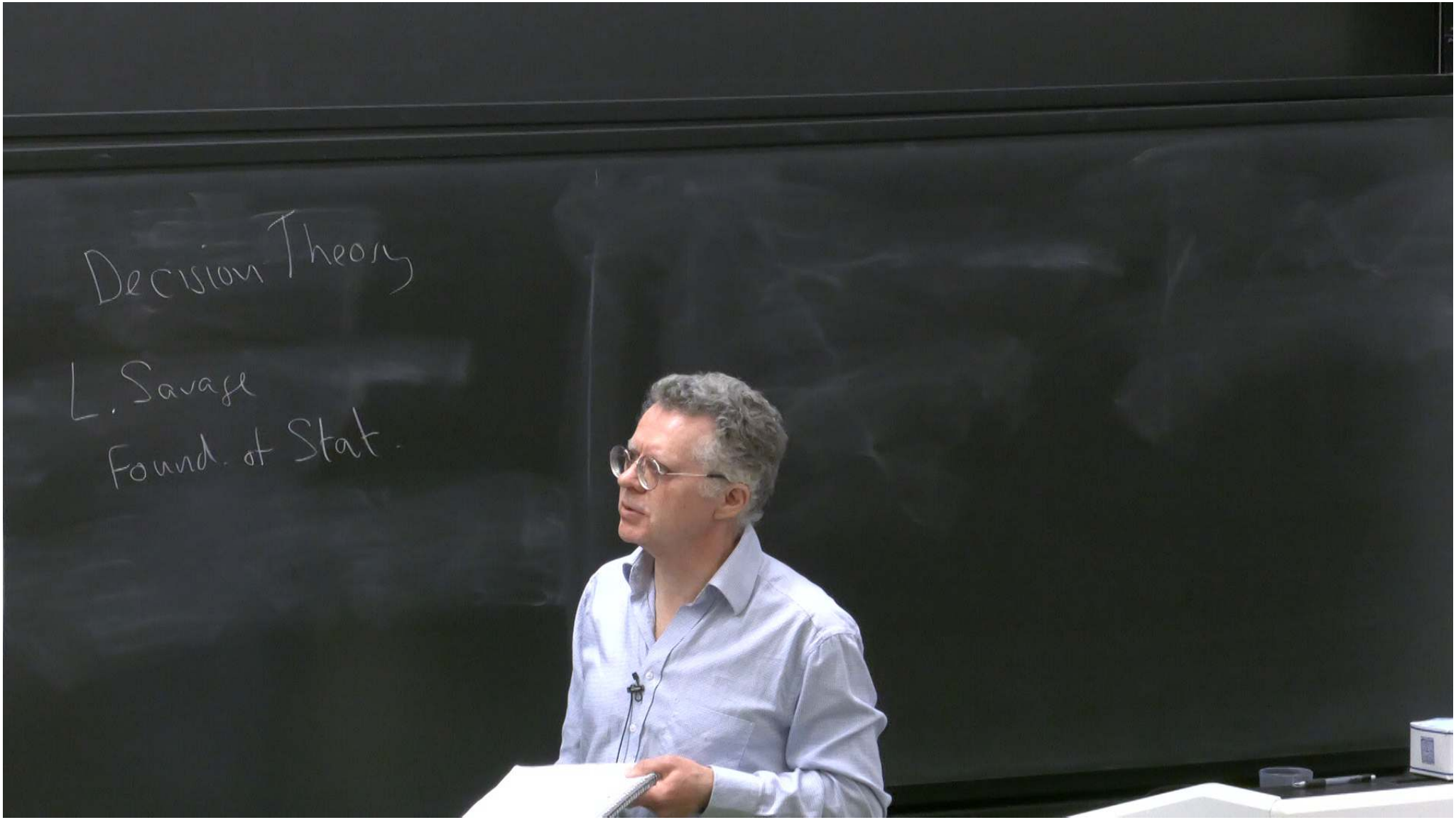
$p = 10^{-2000}$


Decision Theory
L. Savage
Found. of Stat.