Title: Lecture - Quantum Foundations, PHYS 639

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Collection/Series: Quantum Foundations (Elective), PHYS 639, January 6 - February 5, 2025

Subject: Quantum Foundations

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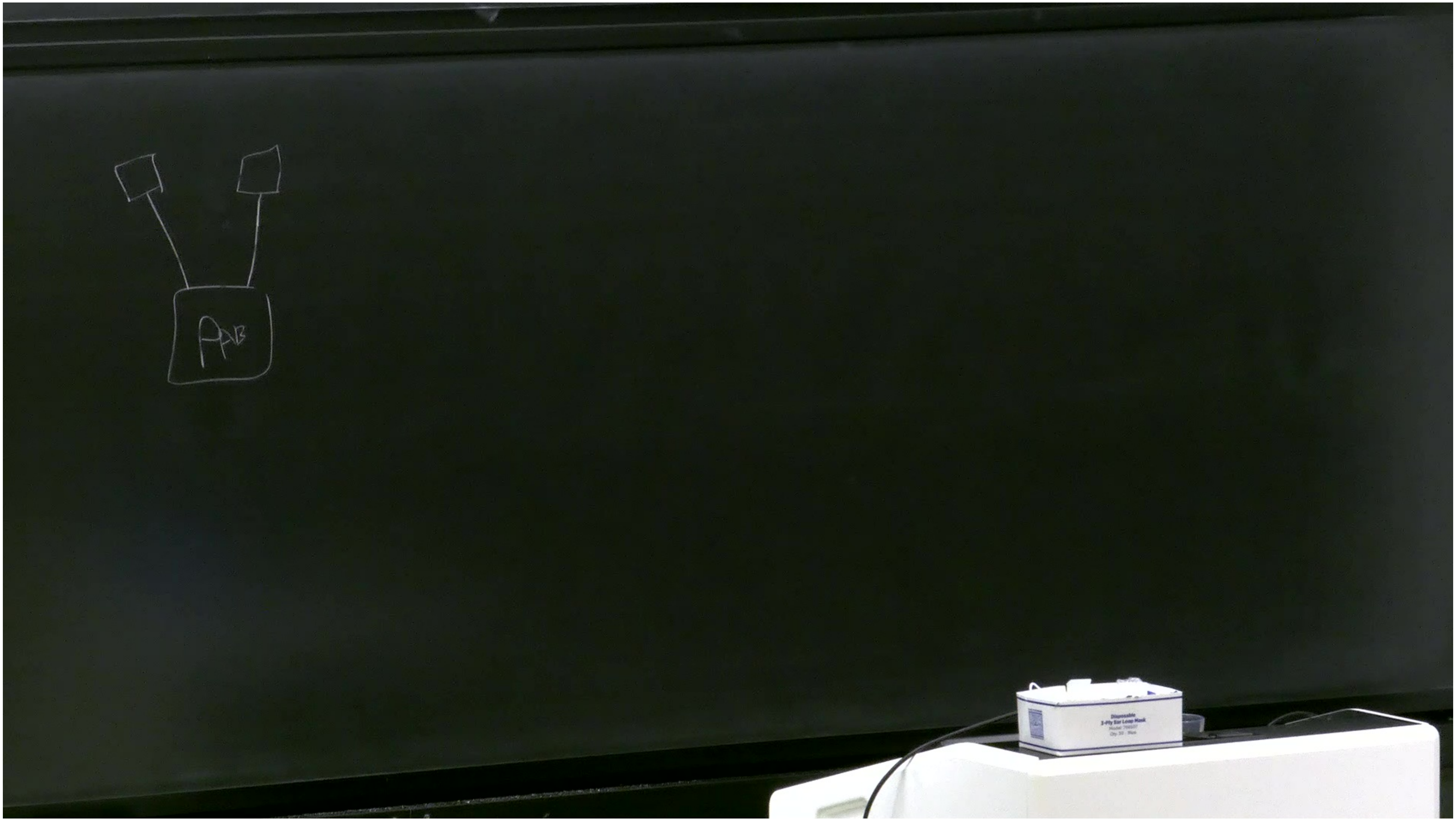
$$\rho = \begin{pmatrix} p_1 & & & \\ & p_2 & & \\ & & \ddots & \\ & & & p_N \end{pmatrix}$$

$$K = N + 2\tfrac{1}{2}N(N-1) = N^2$$

$$\mathcal{H}_{AB} = \mathcal{H}_A \otimes \mathcal{H}_B$$

$$N_{AB} = N_A N_B$$

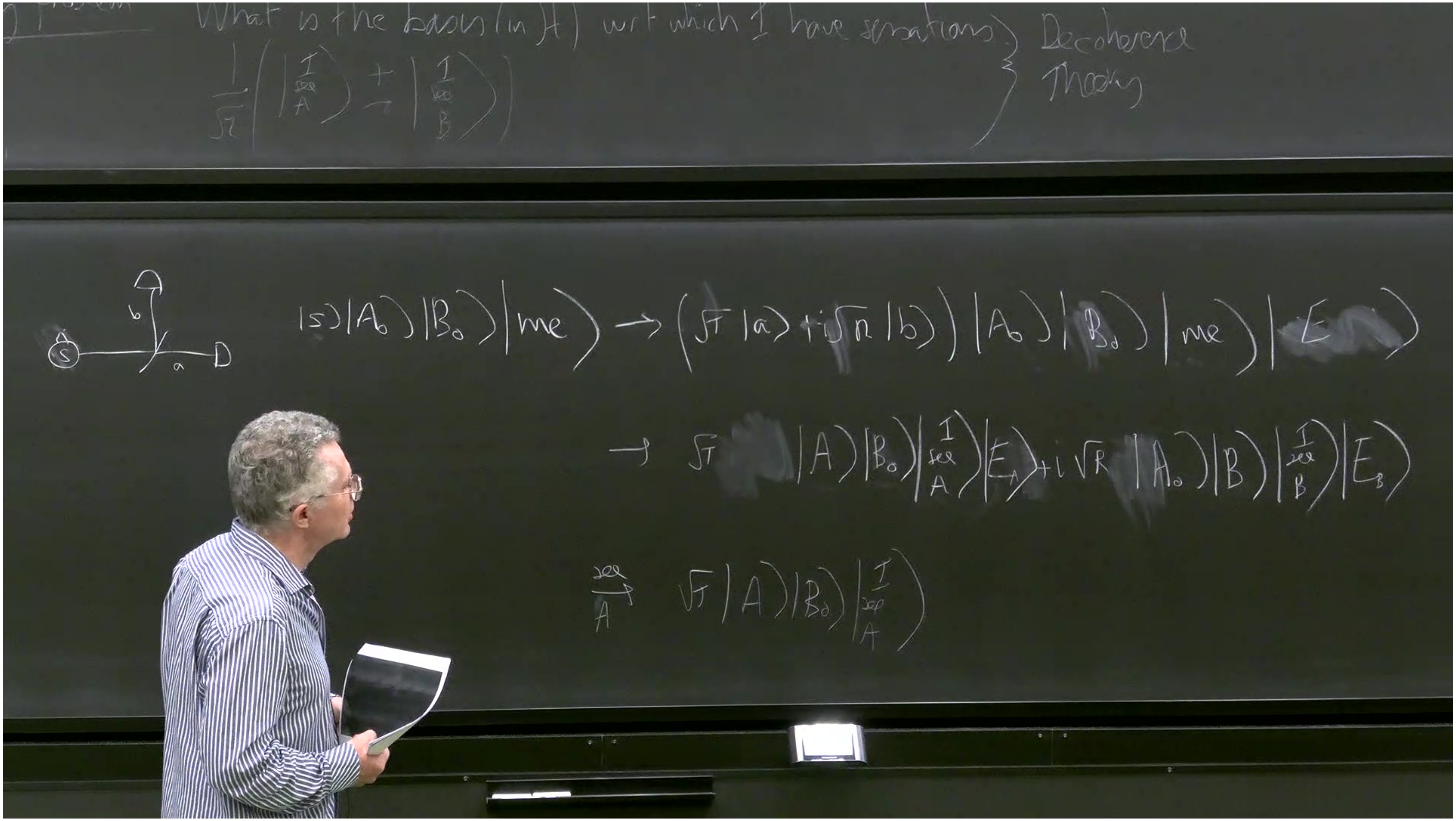
$$K_{AB} = K_A K_B$$

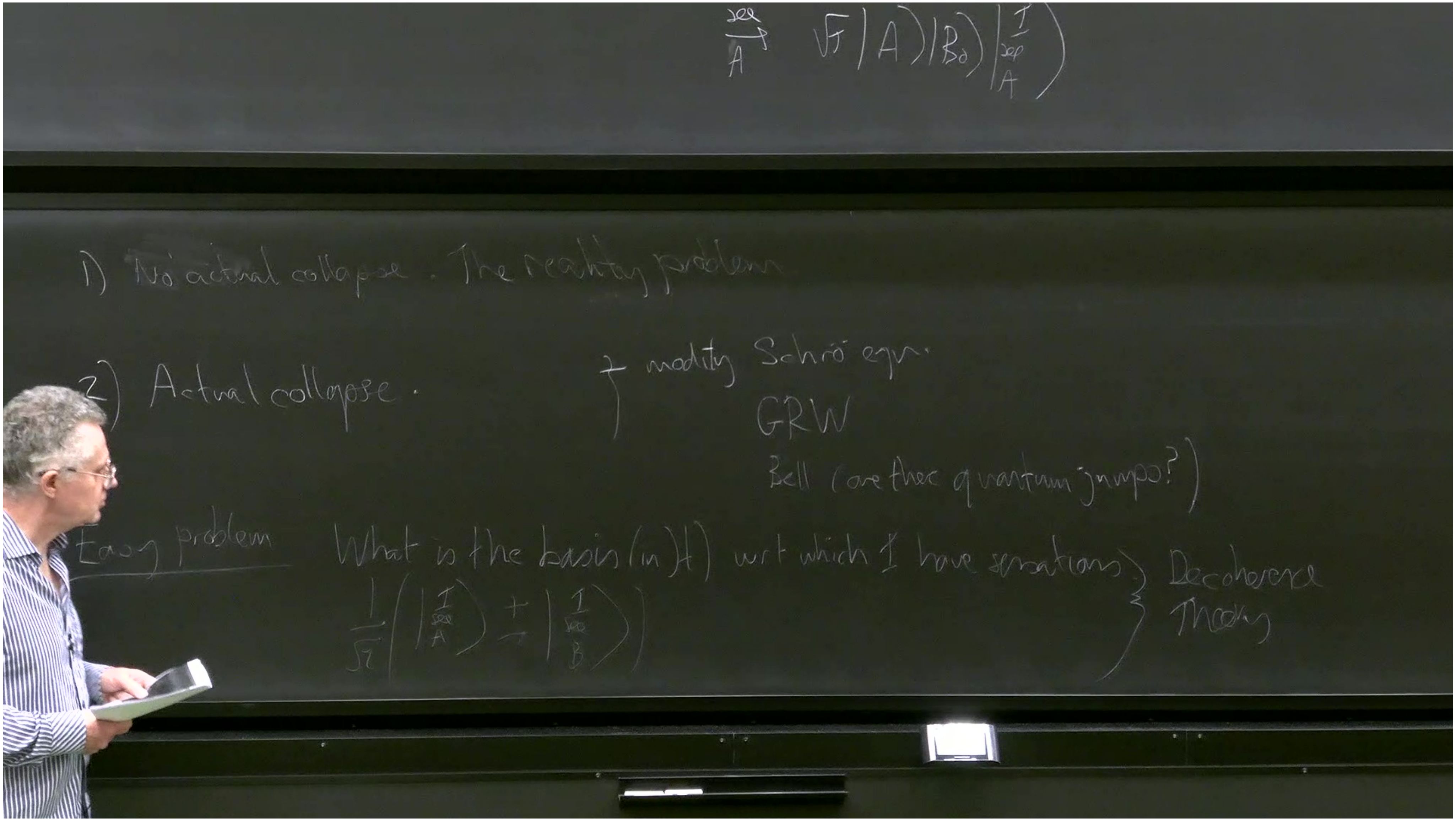

ρ_{AB}

$$|s\rangle|A_0\rangle|B_0\rangle|me\rangle \to \left(\sqrt{T}|a\rangle + i\sqrt{R}|b\rangle\right)|A_0\rangle|B_0\rangle|me\rangle$$

$$\to \sqrt{T}\,|A\rangle|B_0\rangle\left|\begin{matrix} I \\ \text{see} \\ A \end{matrix}\right\rangle + i\sqrt{R}\,|A_0\rangle|B\rangle\left|\begin{matrix} I \\ \text{see} \\ B \end{matrix}\right\rangle$$

$$\xrightarrow[A]{\text{see}} \sqrt{T}\,|A\rangle|B_0\rangle\left|\begin{matrix} I \\ \text{see} \\ A \end{matrix}\right\rangle$$


What is the basis (in H) wrt which I have sensations
Decoherence Theory


1) No actual collapse. The reality problem
2) Actual collapse.
modify Schrö eqn.
GRW
Bell (are there quantum jumps?)
Easy problem
What is the basis (in H) wrt which I have sensations
Decoherence
Theory

1) No actual collapse. The reality problem

2) Actual collapse. — modify Schrö eqn.

GRW

Bell (are there quantum jumps?)

Easy problem — What is the basis (in $\mathcal{H}$) wrt which I have sensations — Decoherence Theory

$$\frac{1}{\sqrt{2}}\left(\left|\begin{smallmatrix} I \\ \text{see} \\ A \end{smallmatrix}\right\rangle + \left|\begin{smallmatrix} I \\ \text{see} \\ B \end{smallmatrix}\right\rangle\right)$$

$$\frac{1}{\sqrt{2}}\left(\left|\begin{matrix}\text{I}\\ \text{see}\\ \text{A}\end{matrix}\right\rangle + \left|\begin{matrix}\text{I}\\ \text{see}\\ \text{B}\end{matrix}\right\rangle\right)$$ } Theory

Hard problem   What actually picks out (the sensation of) a definite outcome?

FAPP

The no cloning theorem

M clones states in $\mathcal{H}_{a_1}$

$$|\psi\rangle_{a_1}|M\rangle_{b_3} \xrightarrow{U} |\psi\rangle_{a_1}|\psi\rangle_{a_2}|M_\psi\rangle_{c_4} \quad \forall\, |\psi\rangle_{a_1} \in \mathcal{H}_{a_1}$$

The no cloning theorem.

M clones states in $\mathcal{H}_{a_1}$

$$|\psi\rangle_{a_1}|M\rangle_{b_3} \xrightarrow{U} |\psi\rangle_{a_1}|\psi\rangle_{a_2}|M_\psi\rangle_{c_4} \qquad \forall\, |\psi\rangle_{a_1} \in \mathcal{H}_{a_1}$$

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

observations } Decoherence Theory

servation or not) a definite outcome?

$U|u\rangle$

$U|v\rangle$

$\langle v|\underbrace{U^\dagger U}_{\mathbb{1}}|u\rangle = \langle v|u\rangle$

$|\psi\rangle_{a_1} |\varphi\rangle_{a_2} |M_\varphi\rangle_{c_\varphi}$

$$\langle\varphi|\psi\rangle \underbrace{\langle M|M\rangle}_{=1} = \langle\varphi|\psi\rangle^2 \langle M_\varphi|M_\psi\rangle$$

$|\psi\rangle = |0\rangle$

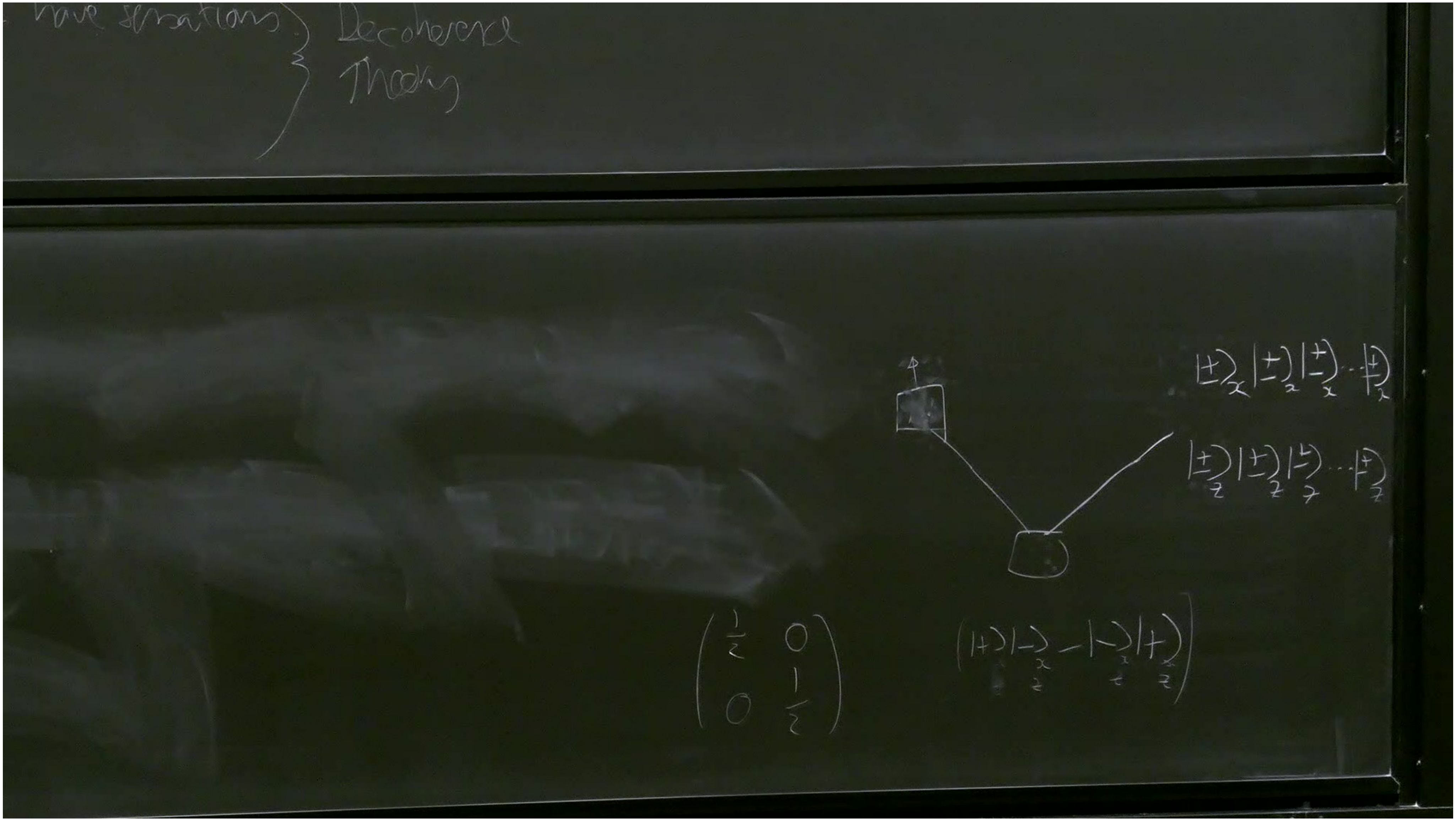
$|\varphi\rangle = \alpha|0\rangle + \beta|1\rangle$

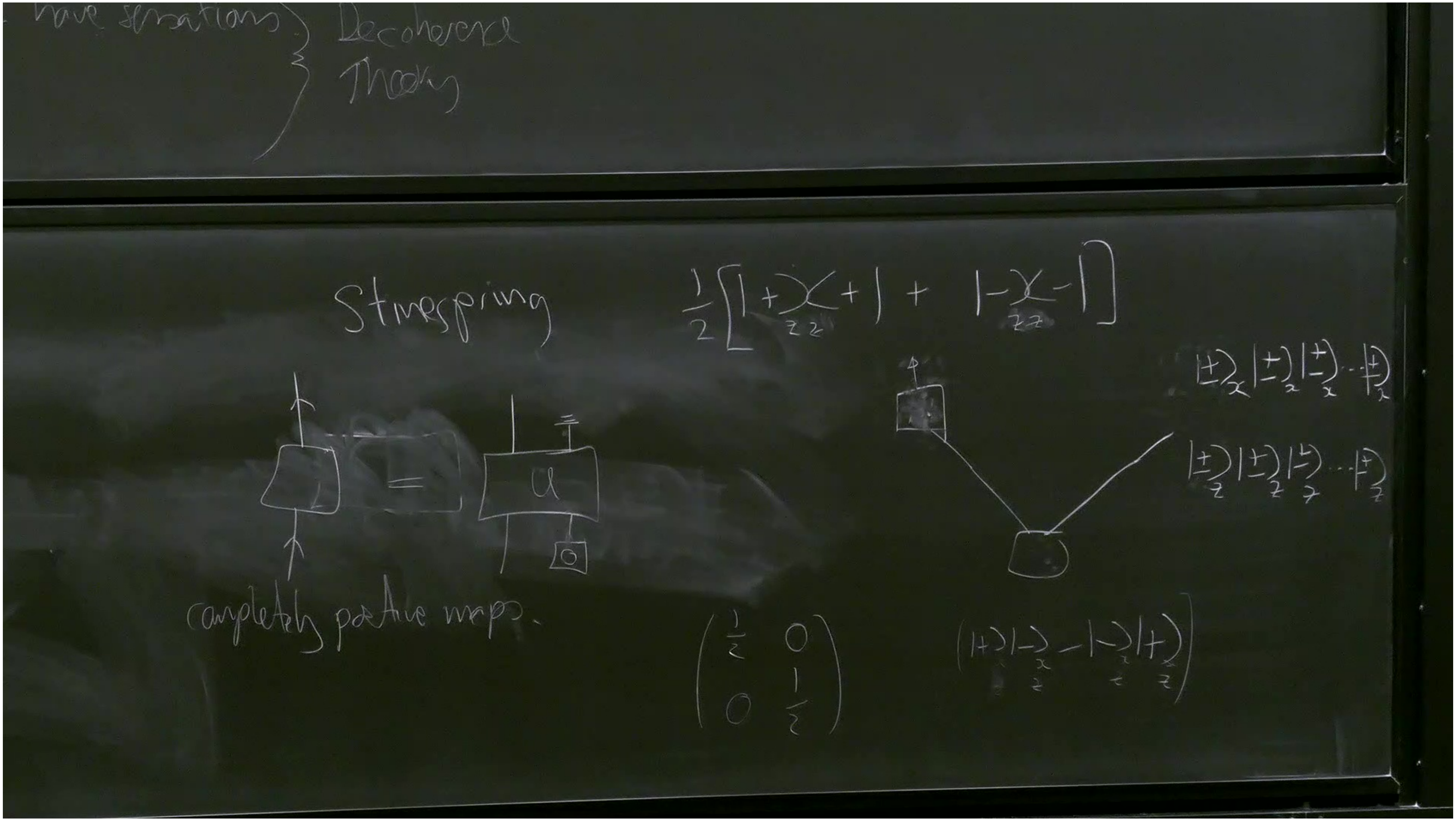
Case 1: $\langle\varphi|\psi\rangle = 0$

Case 2: $\langle\varphi|\psi\rangle \neq 0$

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

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


have sensations
Decoherence
Theory


have sensations
Decoherence
Theory
Stinespring
completely positive maps.