Title: Quantum Foundations Lecture - 230116

Speakers: Lucien Hardy

Collection: Quantum Foundations (2022/2023)

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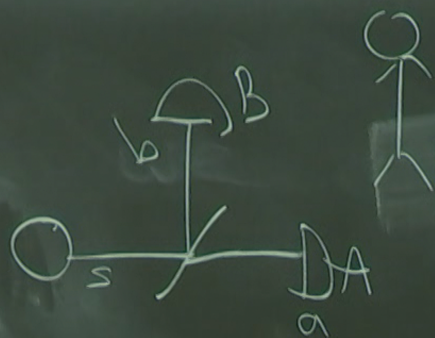
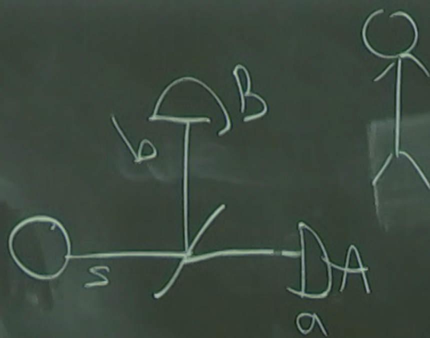



$$|s\rangle|A_0\rangle|B_0\rangle|me\rangle \to \left(\frac{1}{\sqrt{2}}|a\rangle + \frac{i}{\sqrt{2}}|b\rangle\right)|A_0\rangle|B_0\rangle|me\rangle$$

$$\to \frac{1}{\sqrt{2}}|A\rangle|B_0\rangle\left|\tfrac{I}{\text{see } A}\right\rangle + \frac{i}{\sqrt{2}}|A_0\rangle|B\rangle\left|\tfrac{I}{\text{see } B}\right\rangle$$




$$|s\rangle|A_0\rangle|B_0\rangle|Me\rangle \to \left(\frac{1}{\sqrt{2}}|a\rangle + \frac{i}{\sqrt{2}}|b\rangle\right)|A_0\rangle|B_0\rangle|Me\rangle$$

$$\to \frac{1}{\sqrt{2}}|A\rangle|B_0\rangle\left|\begin{smallmatrix}\text{I}\\ \text{see}\\ \text{A}\end{smallmatrix}\right\rangle + \frac{i}{\sqrt{2}}|A_0\rangle|B\rangle\left|\begin{smallmatrix}\text{I}\\ \text{see}\\ \text{B}\end{smallmatrix}\right\rangle$$

$$\to \frac{1}{\sqrt{2}}|A\rangle|B_0\rangle\left|\begin{smallmatrix}\text{I}\\ \text{see}\\ \text{A}\end{smallmatrix}\right\rangle$$

$\ldots_0\rangle|me\rangle$ → The reality problem (no collapse)

$A_0\rangle|B\ldots\rangle|\text{I see } B\rangle$ → The collapse problem (we do collapse) what qualifies as measurement?

There are collapse models. P. Pearl. GRW modify Schrö eqn

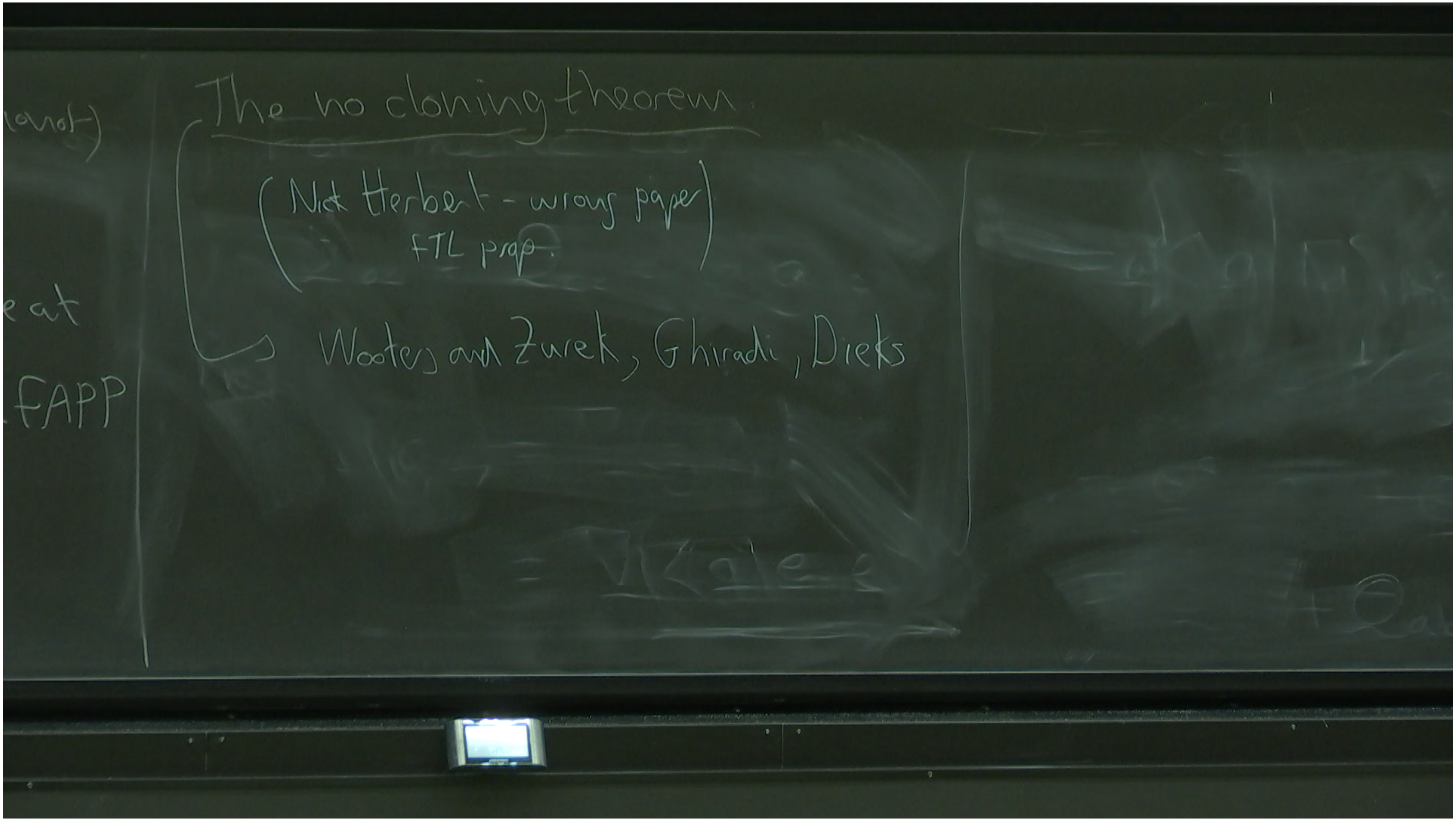
Two components to solving the measurement problem.

1) Easy problem: What basis is (sensation of) definite outcomes wrt?

why not $\frac{1}{\sqrt{2}}\left(|\text{I see } A\rangle + |\text{I see } B\rangle\right)$ Use decoherence theory.

2) Hard problem What picks out the (sensation of) actually having a definite experience?

FAPP as long as choose projections to be at sufficiently macroscopic level it is impossible FAPP to reinterfere.


The no cloning theorem.
Nick Herbert - wrong paper
FTL prop.
Wooters and Zurek, Ghiradi, Dieks
FAPP

Imagine we have a machine M that clones states in $\mathcal{H}_{a_1}$

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

want it to work for all states

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

$$\mathcal{H}_{tot} = \mathcal{H}_{a_1}\otimes\mathcal{H}_{a_2}\otimes ?$$

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

either

$$\langle\varphi|\psi\rangle = 0$$

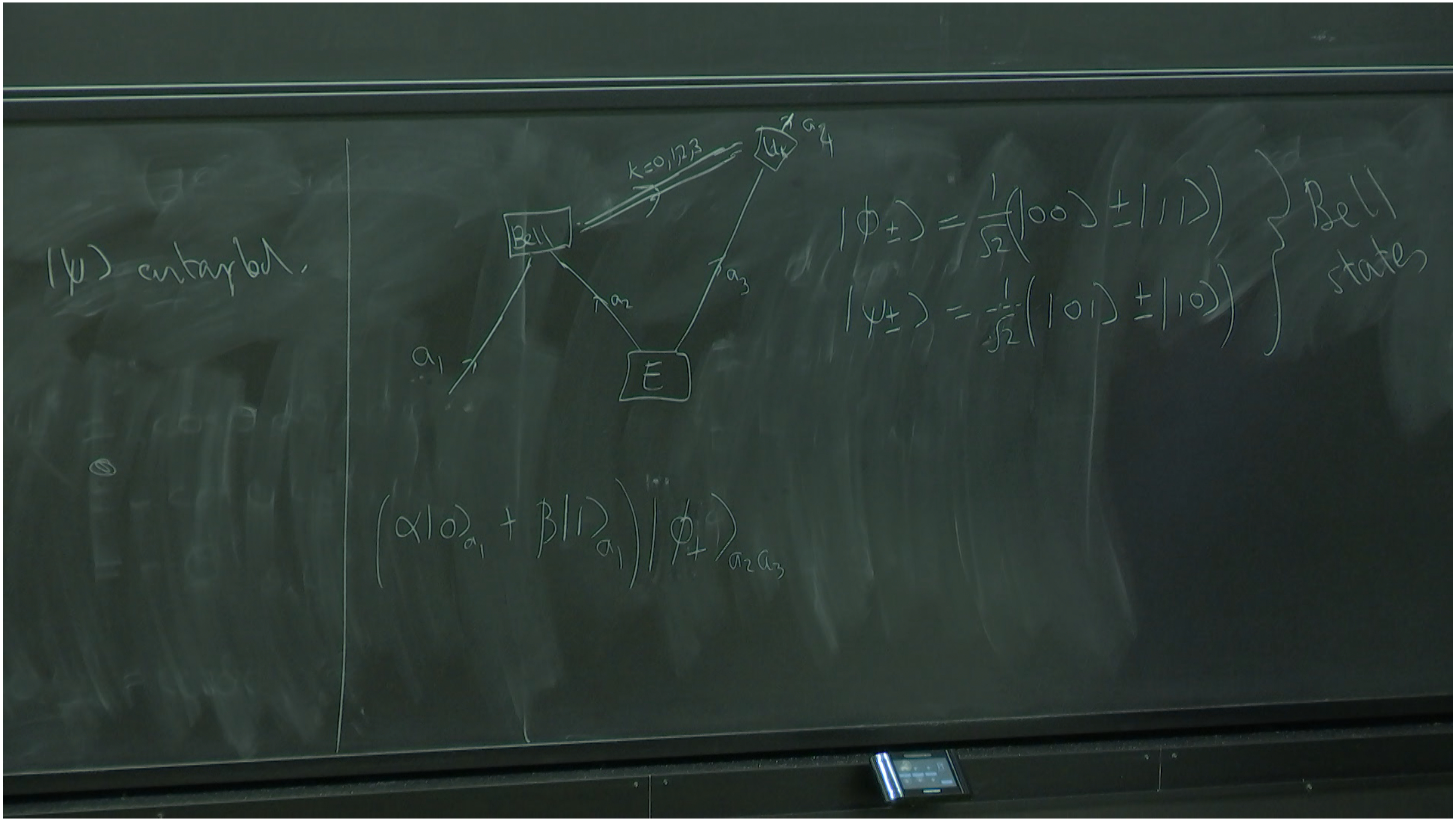
or

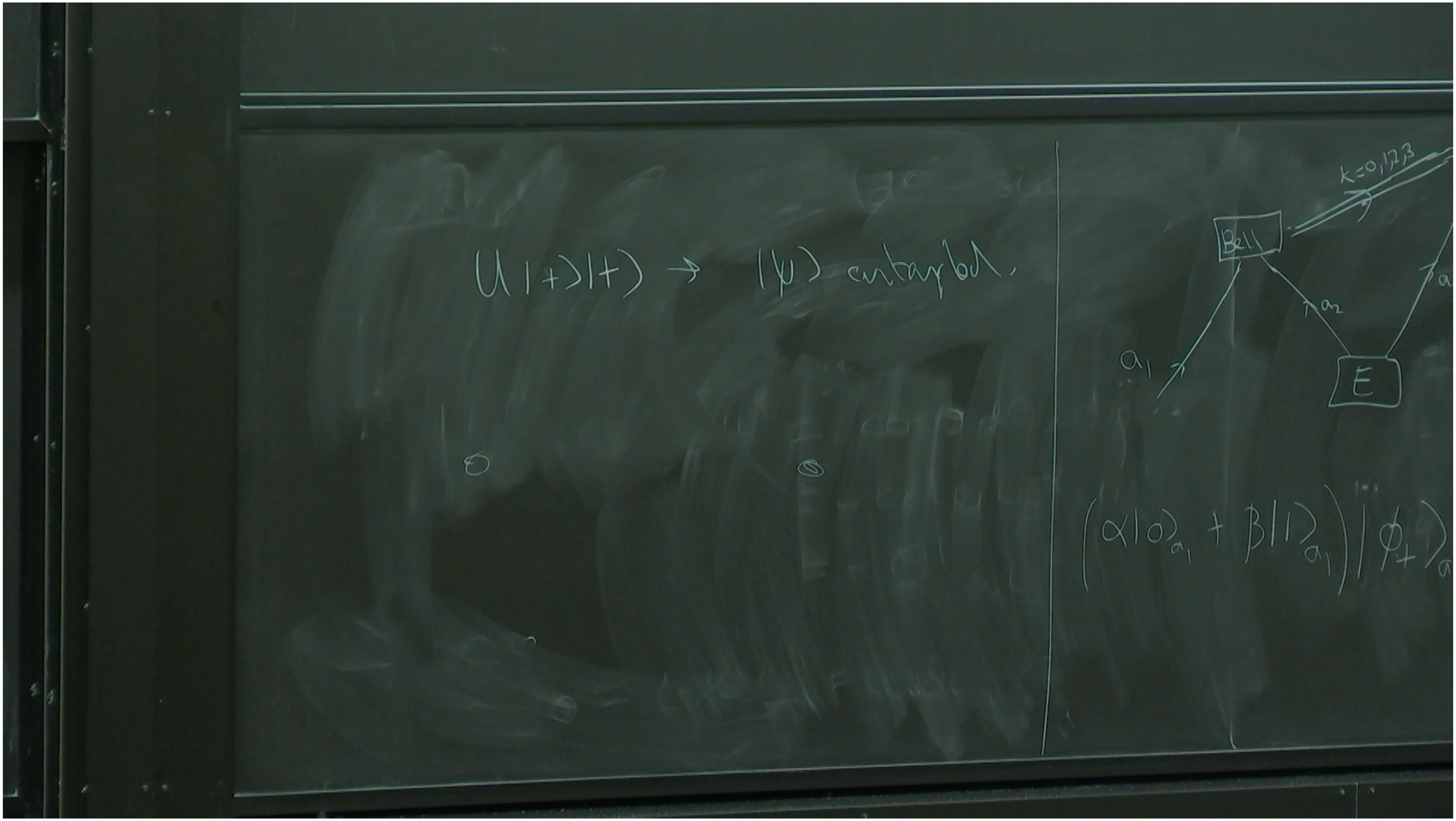
$$1 = \langle\varphi|\psi\rangle\langle M_\varphi|$$

$$\left(|+_z\rangle_{a_1}|-_z\rangle_{a_2} - |-_z\rangle_{a_1}|+\rangle_{a_2}\right) \xrightarrow[\text{meas}]{\text{Z basis}} |+_z\rangle|-_z\rangle \text{ or } |-_z\rangle|+_z\rangle$$

$$\left(|+_x\rangle_{a_1}|-_x\rangle_{a_2} - |-_x\rangle_{a_1}|+_x\rangle_{a_2}\right) \xrightarrow[\text{meas}]{\text{x basis}} |+_x\rangle|-_x\rangle \text{ or } |-_x\rangle|+_x\rangle$$

$$|+_z\rangle \to |+\rangle_z|+\rangle_z$$


|ψ⟩ entangled.
Bell
E
k=0,1,2,3
a1
a2
a3
a4
|φ±⟩ = 1/√2 (|00⟩ ± |11⟩)
|ψ±⟩ = 1/√2 (|01⟩ ± |10⟩)
Bell states
(α|0⟩a1 + β|1⟩a1) |φ+⟩a2a3


U|+⟩|+⟩ → |ψ⟩ entangled.
k=0,1,2,3
Bell
a1
a2
E
(α|0⟩a1 + β|1⟩a1)|φ+⟩a