Title: Quantum Foundations Lecture - 230111

Speakers: Lucien Hardy

Collection: Quantum Foundations (2022/2023)

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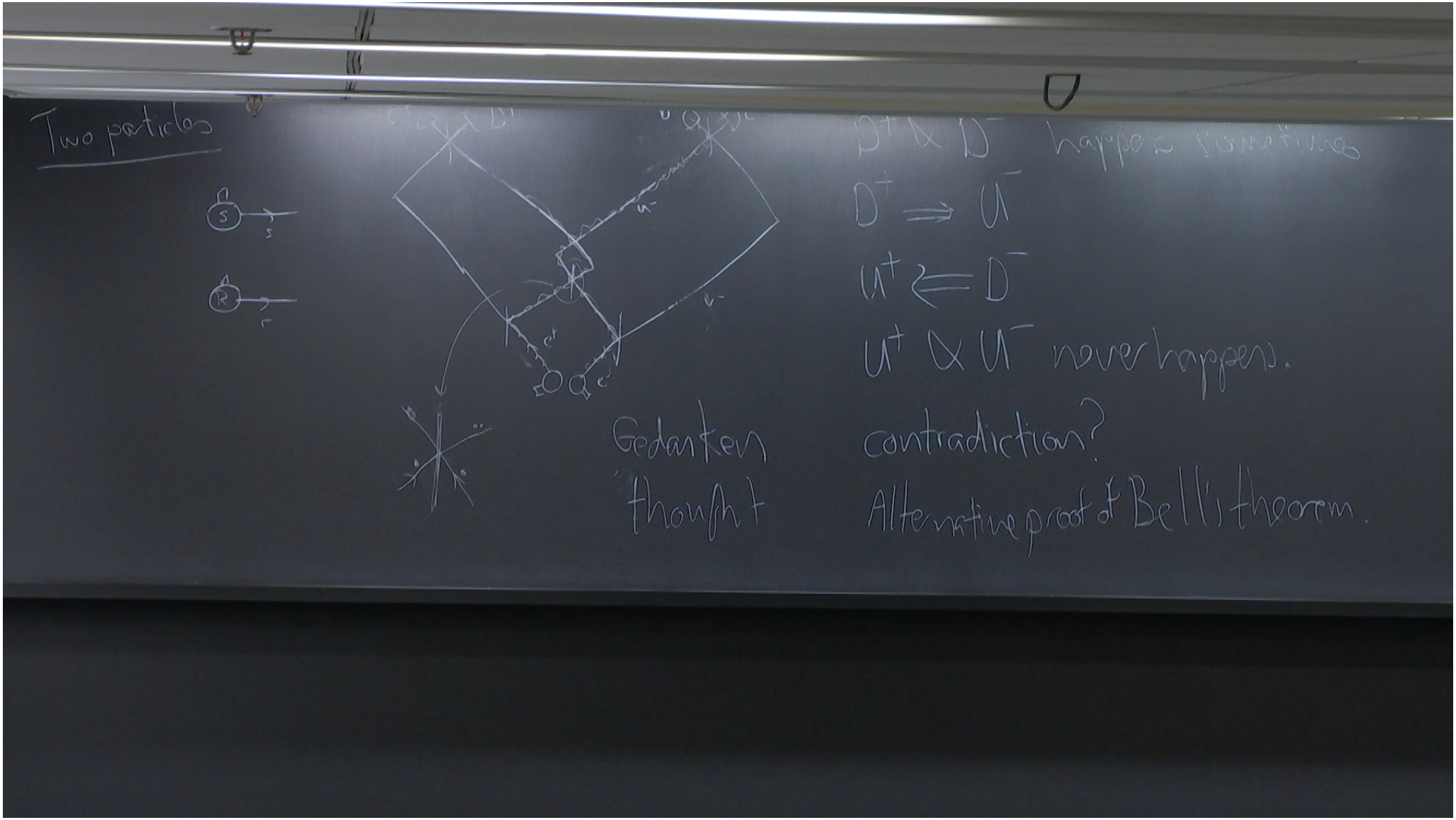
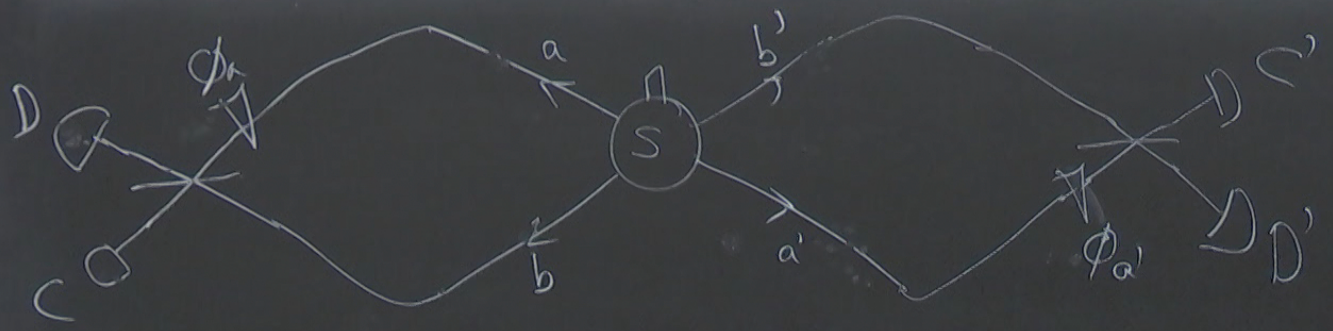

Two particles
S
R
Gedanken
thought
$D^+ \not\propto D^-$ happens sometimes
$D^+ \Longrightarrow U^-$
$U^+ \Longleftarrow D^-$
$U^+ \not\propto U^-$ never happens.
contradiction?
Alternative proof of Bell's theorem.



$(\phi_a + \phi_{a'})$ Rarity and Tapster 1990's.

Violates Bell inequalities.

Axioms for QT for pure states

① Associated with each system, a, is a Hilbert space $\mathcal{H}_{a_1}$ of dimension N_a where a is the system type and 1 is the instance.

② for a composite system ($a_1 a_2 b_3 c_4$ for example) the Hilbert space is the tensor product of the Hilbert space for the components ($\mathcal{H}_{a_1} \otimes \mathcal{H}_{a_2} \otimes \mathcal{H}_{b_3} \otimes \mathcal{H}_{c_4}$ in our example).

③ The state of a system (pure) at any given time t is an element of the Hilbert space $\mathcal{H}$. $|\psi\rangle \in \mathcal{H}$.

④ Evolution. Two cases

(a) When there is no measurement the state evolves unitarily

$$|\psi\rangle \rightarrow \hat{U}|\psi\rangle \quad (\hat{U}^\dagger U = \mathbb{1})$$

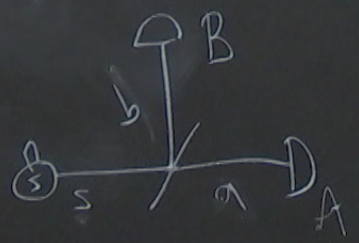
(b) When there is a measurement the state is projected with the projector associated with the measurement outcome we see

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

(5) The probability of a given measurement outcome is given by the square modulus of the amplitude in front of the state after projection

$$\text{prob} = \left(\langle\psi|P\,P|\psi\rangle\right) = \langle\psi|P|\psi\rangle$$ the Born rule.

The measurement problem



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

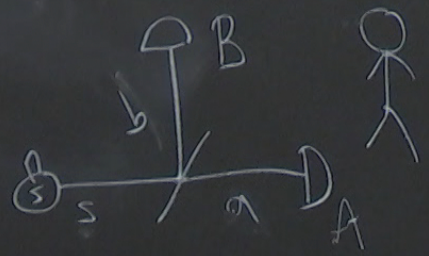
$$\rightarrow \frac{1}{\sqrt{2}}|A\rangle|B_0\rangle + \frac{i}{\sqrt{2}}|A_0\rangle|B\rangle$$

A clicks $\frac{1}{\sqrt{2}}|A\rangle|B_0\rangle$ prob $= \frac{1}{2}$.

A dilema

① The reality problem. No actual collapse. There is a discrepancy between what w
and the actual state (that has no definite outcome)

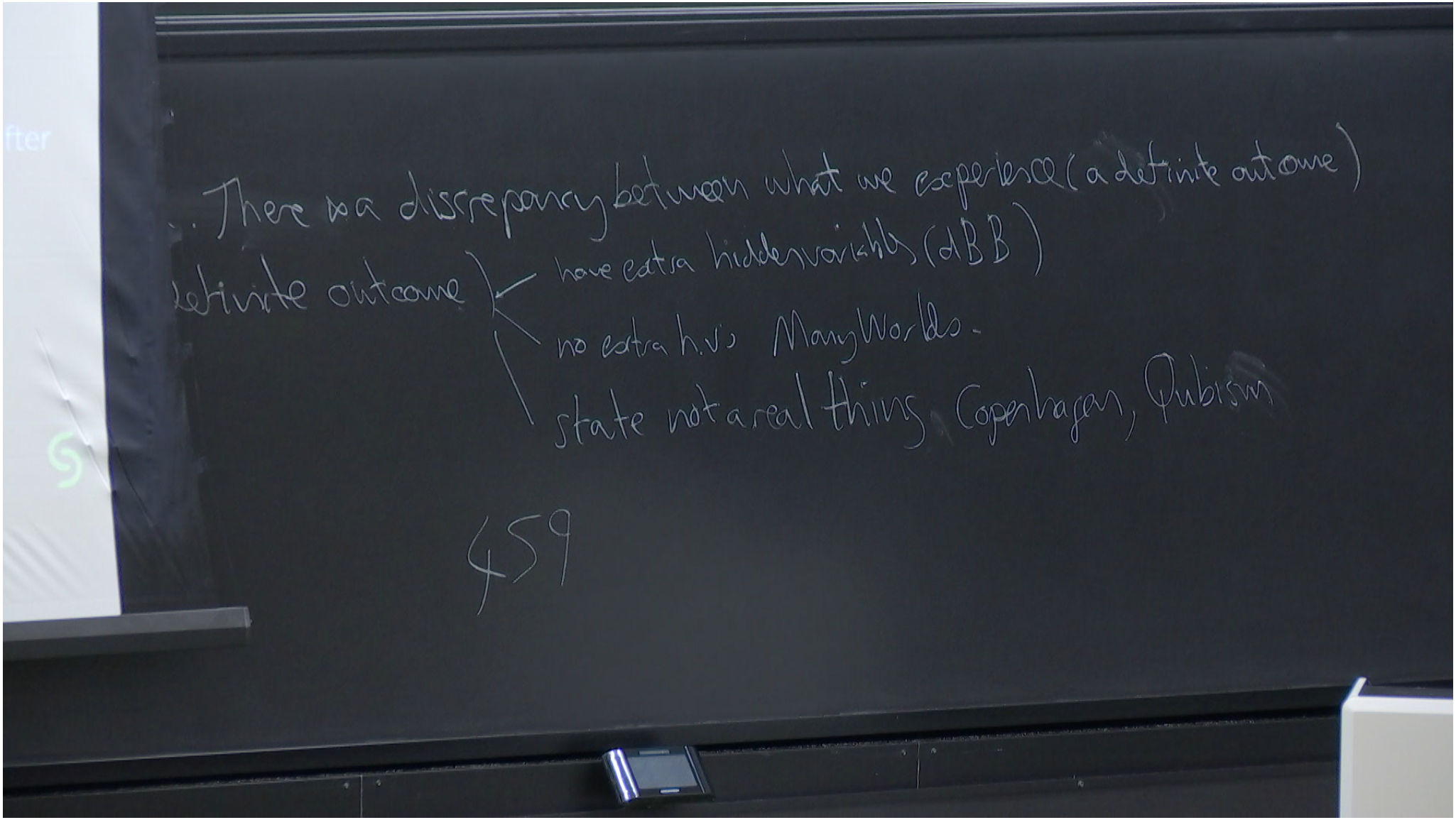
The measurement problem



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

$$\to \frac{1}{\sqrt{2}}|A\rangle|B_0\rangle|\overset{I}{\underset{A}{See}}\rangle + \frac{i}{\sqrt{2}}|A_0\rangle|B\rangle|\overset{I}{\underset{B}{See}}\rangle$$

A clicks $\frac{1}{\sqrt{2}}|A\rangle|B_0\rangle$ prob $= \frac{1}{2}$.


There is a discrepancy between what we experience (a definite outcome)
definite outcome
have extra hidden variables (dBB)
no extra h.v.s Many Worlds.
state not a real thing Copenhagen, Qubism
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A dilema

① The reality problem. No actual collapse. There is a discrepancy
and the actual state (that has no definite outcome) ← ha
no
st

②

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