Title: Lecture - Quantum Foundations, PHYS 639

Speakers: Lucien Hardy

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

Subject: Quantum Foundations

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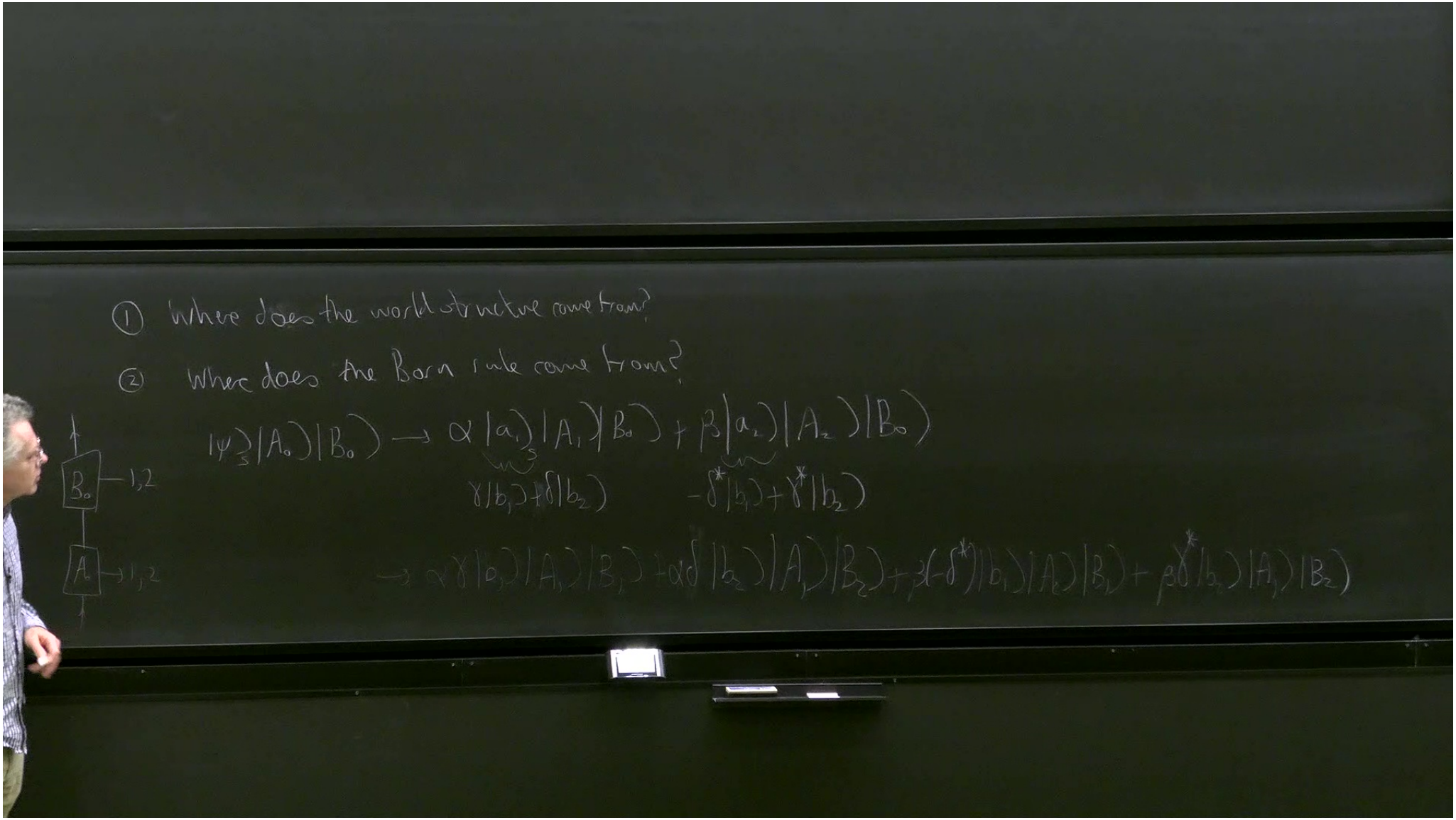
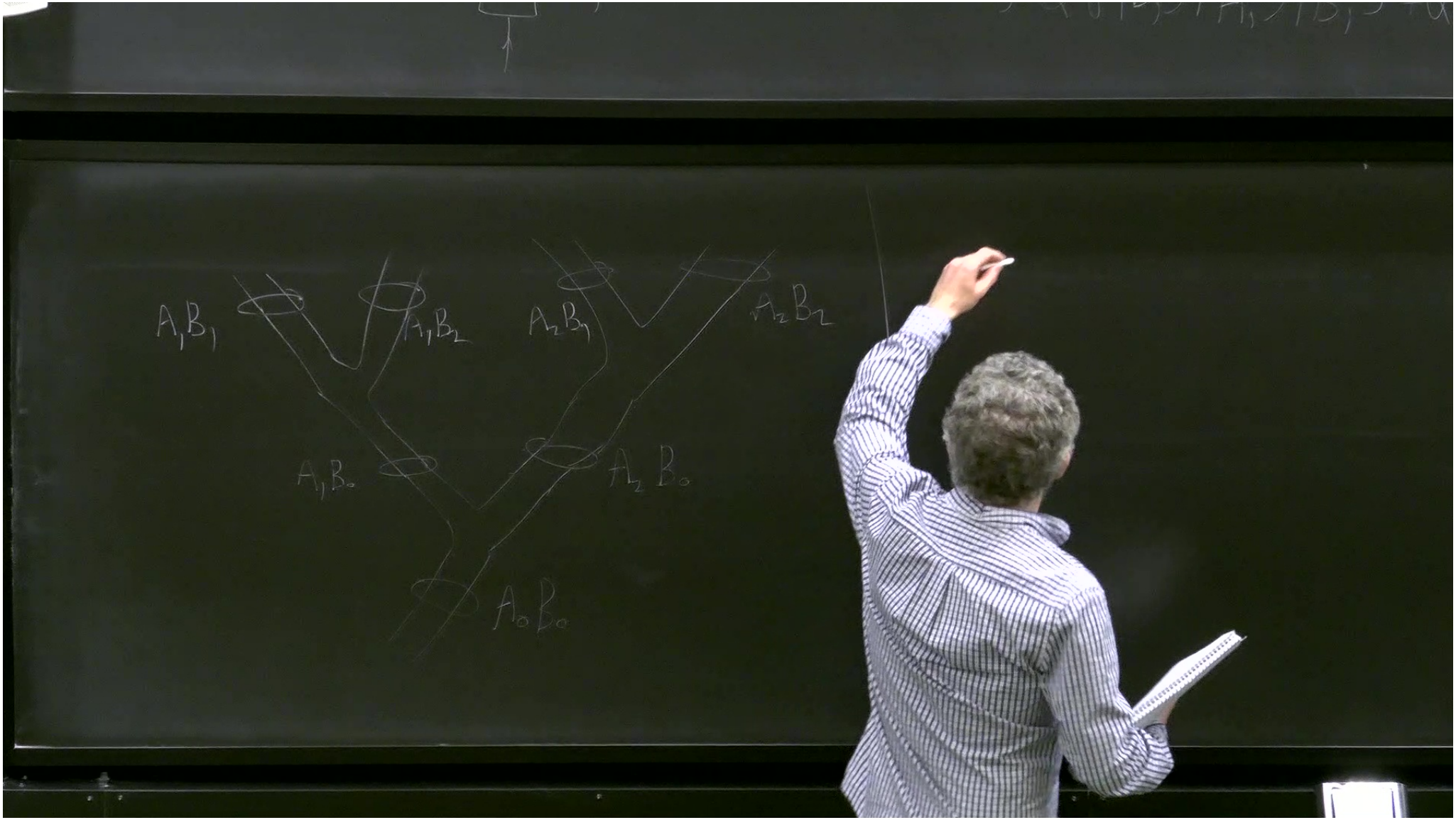
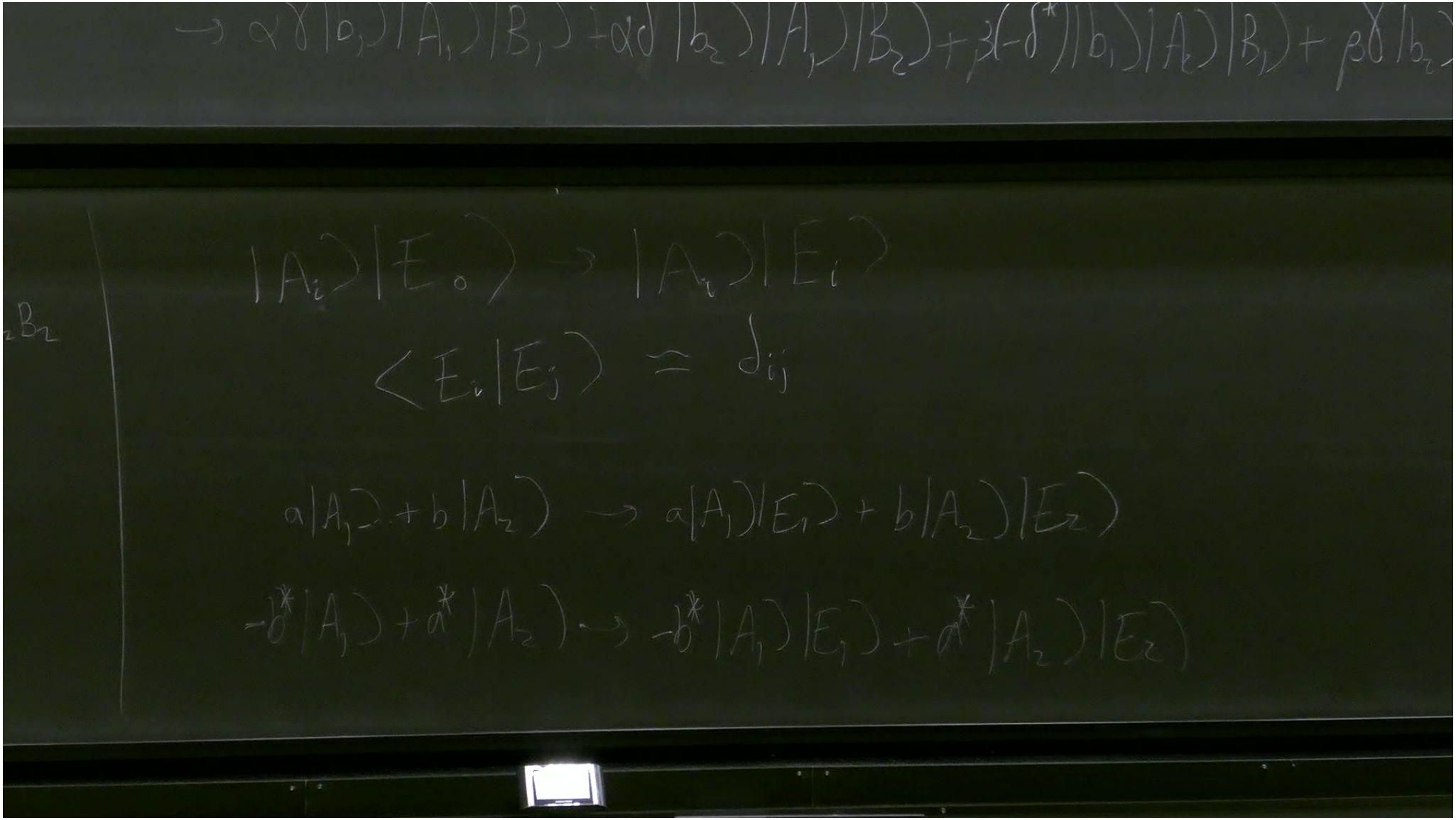
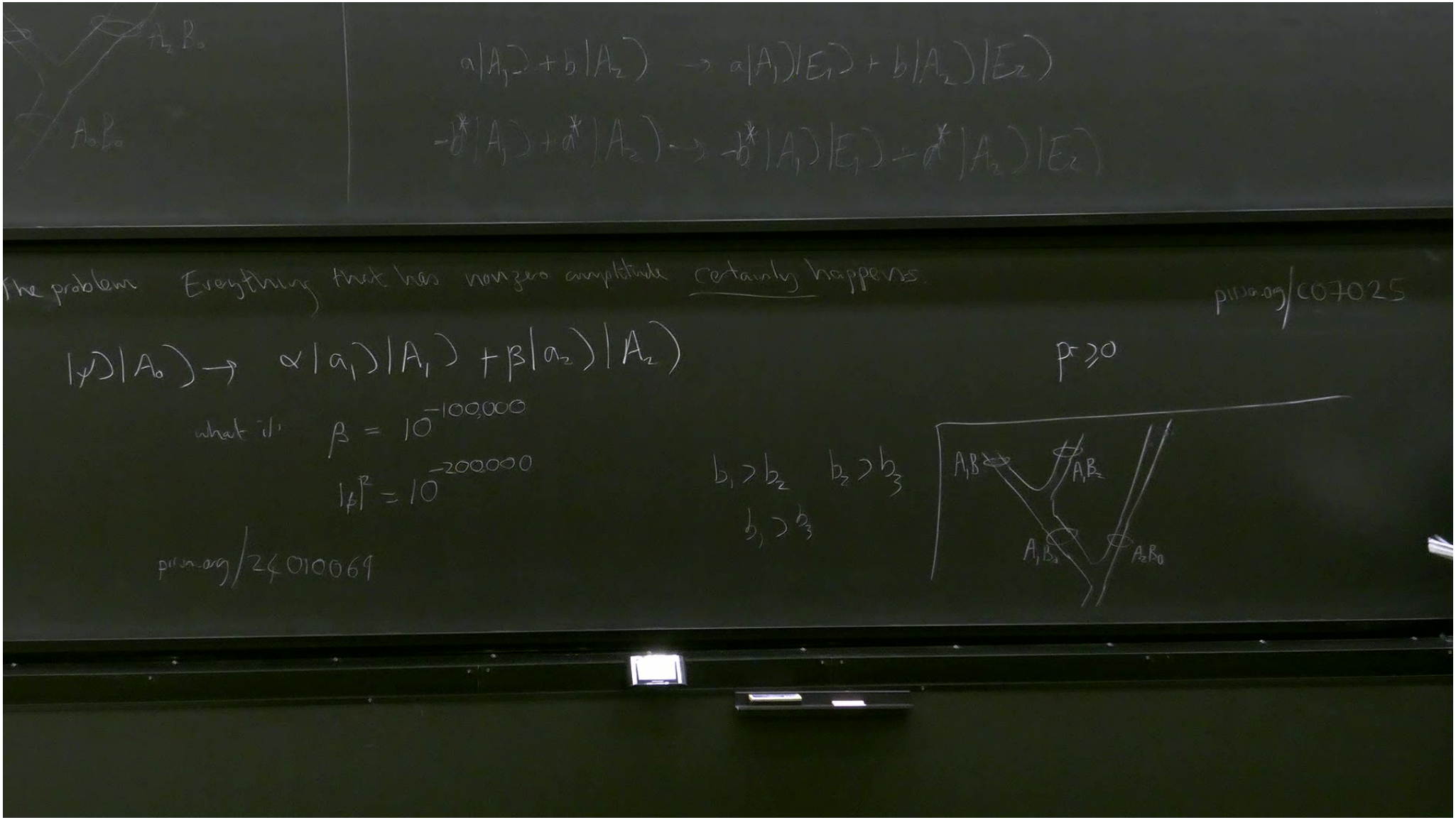

① Where does the world structure come from?
② Where does the Born rule come from?
$|\psi_S\rangle|A_0\rangle|B_0\rangle \rightarrow \alpha|a_1\rangle|A_1\rangle|B_0\rangle + \beta|a_2\rangle|A_2\rangle|B_0\rangle$
$\gamma|b_1\rangle+\delta|b_2\rangle \qquad -\delta^*|b_1\rangle+\gamma^*|b_2\rangle$
$\rightarrow \alpha\gamma|b_1\rangle|A_1\rangle|B_1\rangle + \alpha\delta|b_2\rangle|A_1\rangle|B_2\rangle + \beta(-\delta^*)|b_1\rangle|A_2\rangle|B_1\rangle + \beta\gamma^*|b_2\rangle|A_2\rangle|B_2\rangle$
B_0 → 1,2
A_0 → 1,2


A_1B_1
A_1B_2
A_2B_1
A_2B_2
A_1B_0
A_2B_0
A_0B_0


$|A_i\rangle|E_0\rangle \to |A_i\rangle|E_i\rangle$
$\langle E_i|E_j\rangle = \delta_{ij}$
$a|A_1\rangle + b|A_2\rangle \to a|A_1\rangle|E_1\rangle + b|A_2\rangle|E_2\rangle$
$-b^*|A_1\rangle + a^*|A_2\rangle \to -b^*|A_1\rangle|E_1\rangle + a^*|A_2\rangle|E_2\rangle$


$A_2 B_0$
$A_0 B_0$
$a|A_1\rangle + b|A_2\rangle \rightarrow a|A_1\rangle|E_1\rangle + b|A_2\rangle|E_2\rangle$
$-b^*|A_1\rangle + a^*|A_2\rangle \rightarrow -b^*|A_1\rangle|E_1\rangle + a^*|A_2\rangle|E_2\rangle$
The problem: Everything that has nonzero amplitude certainly happens.
$|\psi\rangle|A_0\rangle \rightarrow \alpha|a_1\rangle|A_1\rangle + \beta|a_2\rangle|A_2\rangle$
what if: $\beta = 10^{-100,000}$
$|\beta|^2 = 10^{-200000}$
$b_1 > b_2 \quad b_2 > b_3$
$b_1 > b_3$
$p \geq 0$
$A_1 B_1$
$A_1 B_2$
$A_1 B_3$
$A_2 B_0$
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$A_2 B_0$

$$a|A_1\rangle + b|A_2\rangle \rightarrow a|A_1\rangle|E_1\rangle + b|A_2\rangle|E_2\rangle$$

$$-b^*|A_1\rangle + a^*|A_2\rangle \rightarrow -b^*|A_1\rangle|E_1\rangle + a^*|A_2\rangle|E_2\rangle$$

Everything that has nonzero amplitude certainly happens.

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$$\rightarrow \alpha|a_1\rangle|A_1\rangle + \beta|a_2\rangle|A_2\rangle$$

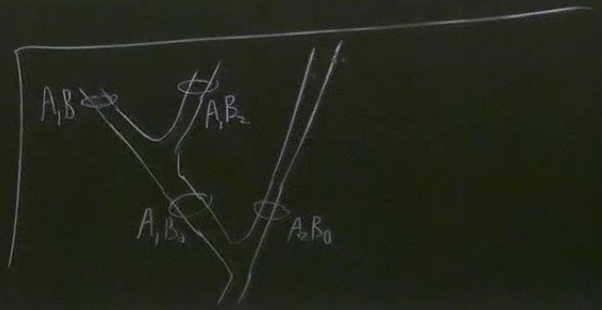
$p \geq 0$

what if: $\beta = 10^{-100,000}$

$|\beta|^2 = 10^{-200000}$

$b_1 > b_2 \quad b_2 > b_3$

$b_1 > b_3$



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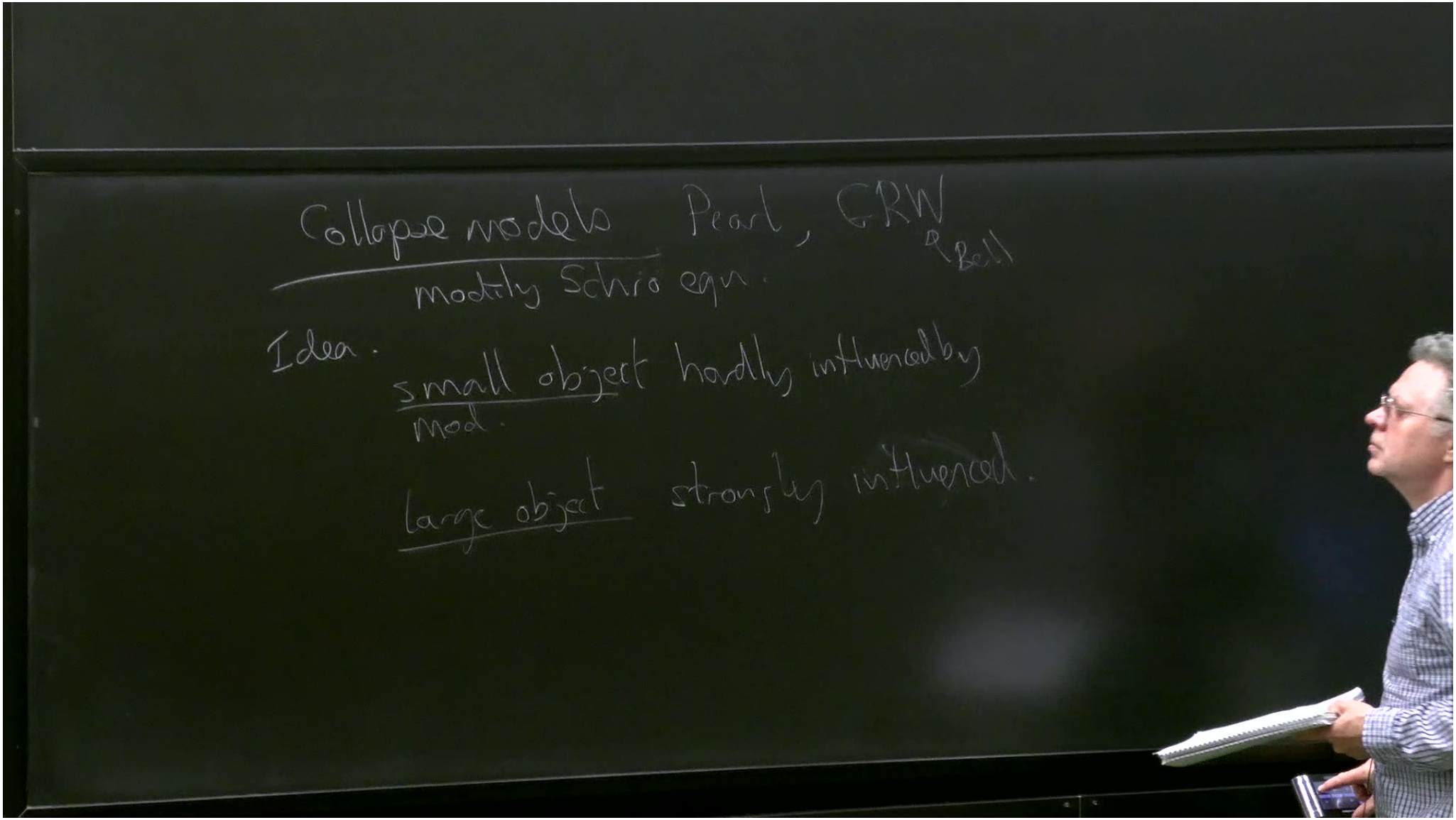
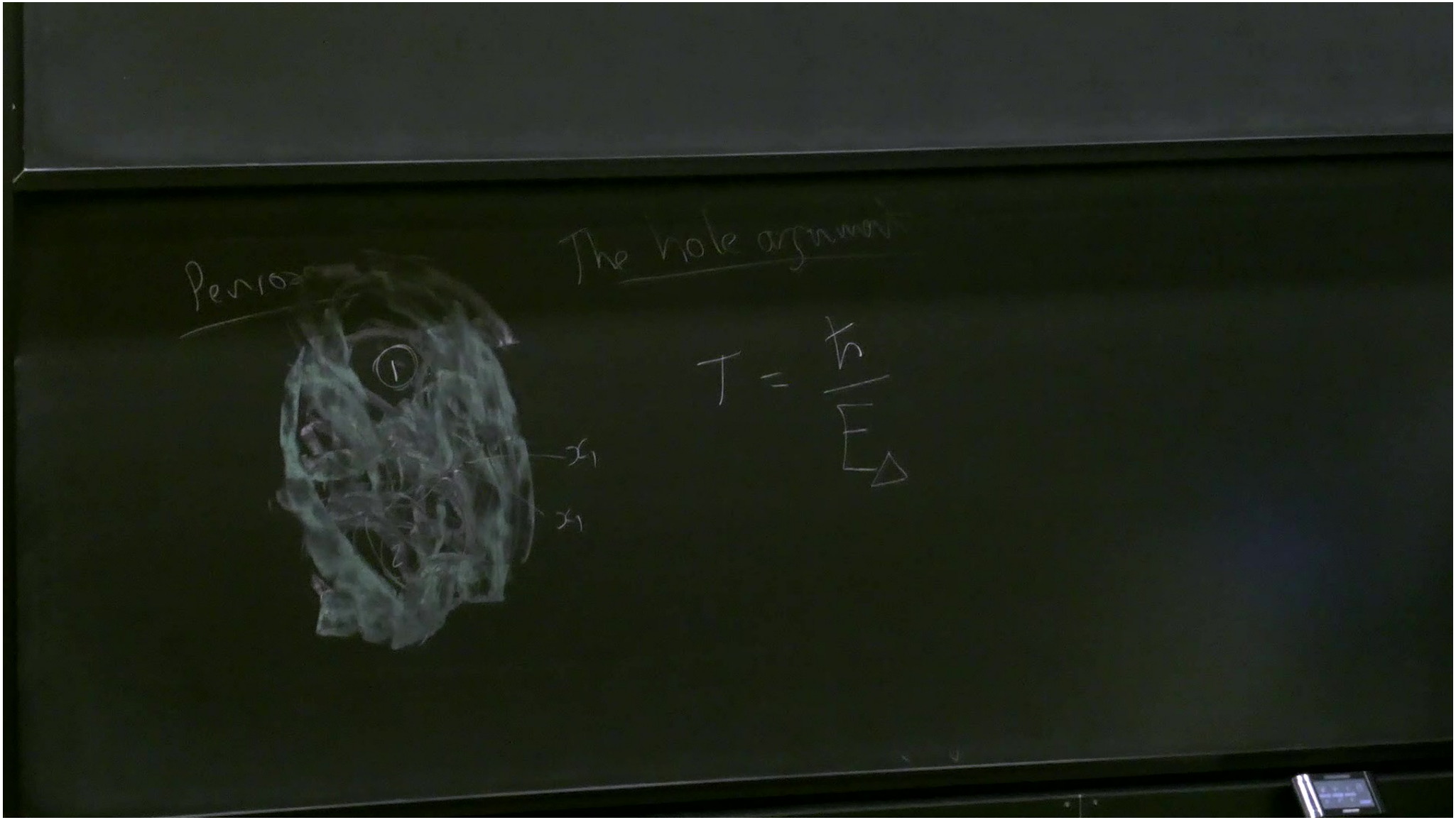
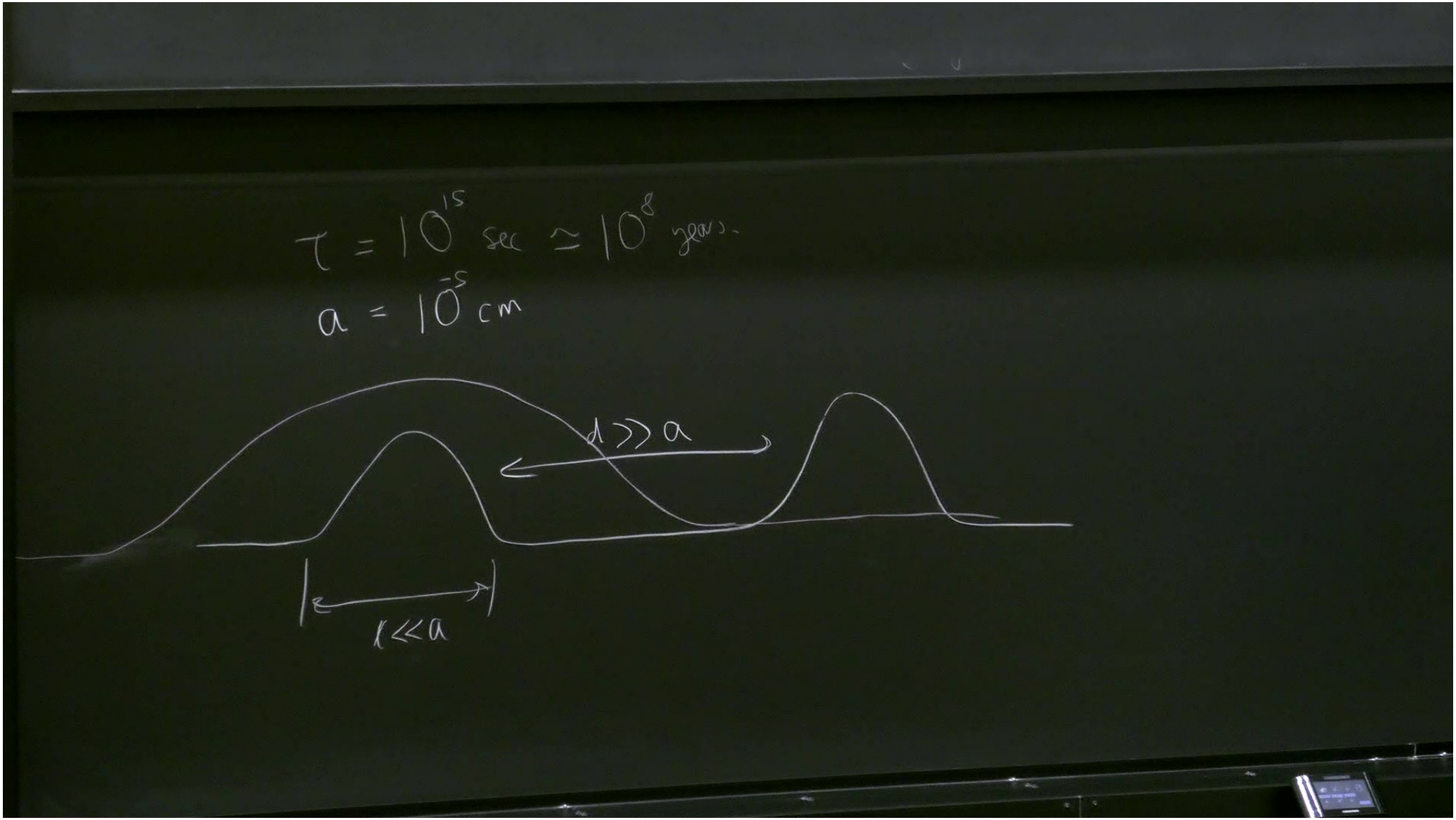
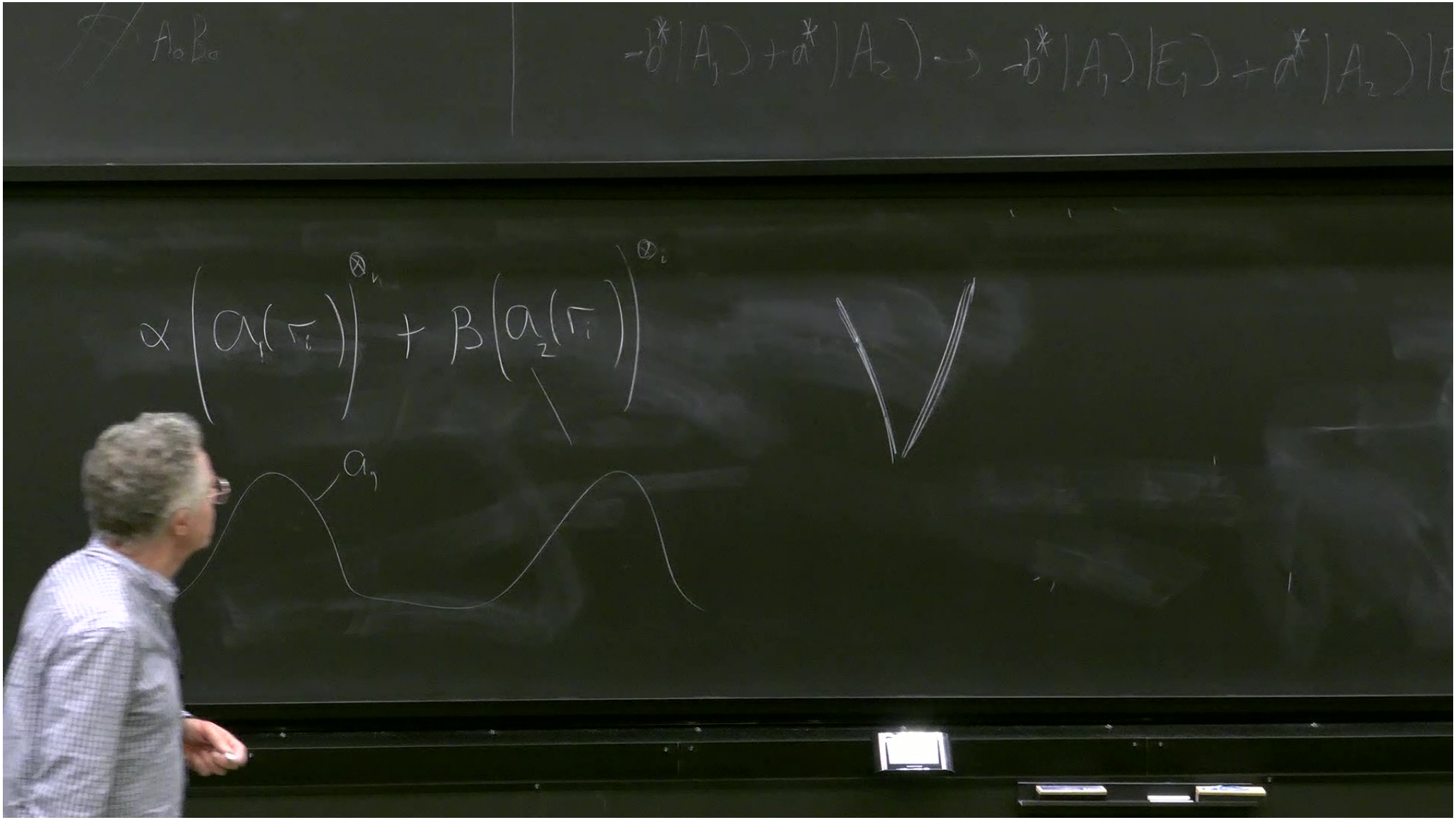

Collapse models Pearl, GRW & Bell
modify Schro eqn.
Idea.
small object hardly influenced by mod.
large object strongly influenced.


Perio
The hole argument
$T = \frac{h}{E_\Delta}$


$\tau = 10^{15}$ sec $\simeq 10^{8}$ years.
$a = 10^{-5}$ cm
$d \gg a$
$\ell \ll a$

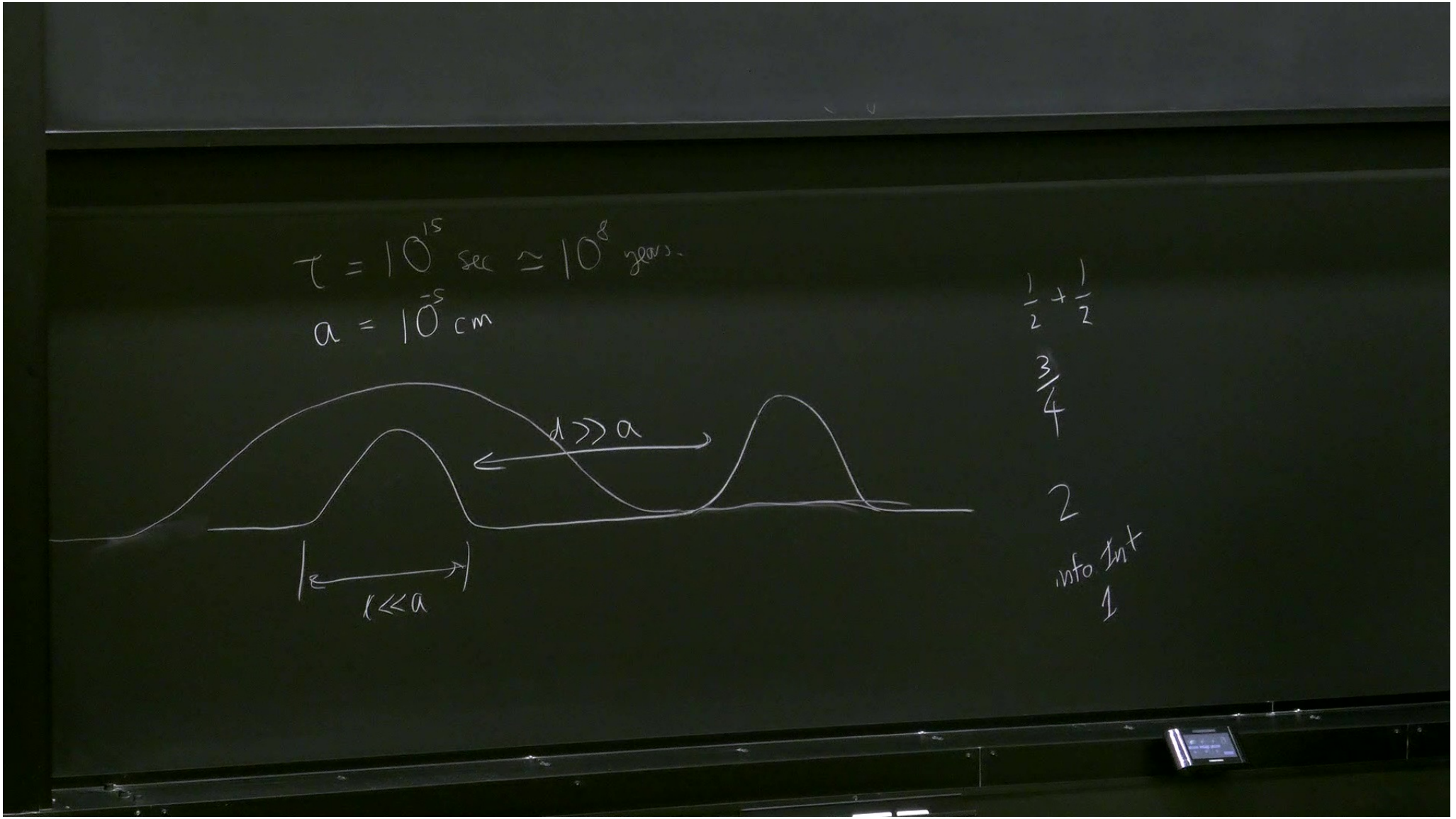

$A_0 B_0$
$-b^* |A_1\rangle + a^* |A_2\rangle \rightarrow -b^* |A_1\rangle |E_1\rangle + a^* |A_2\rangle$
$\propto \left(a_1(r_i) \right)^{\otimes_1} + B \left(a_2(r_i) \right)^{\otimes_i}$
a_1

$|A_2\rangle \rightarrow -b^*|A_1\rangle|E_1\rangle + a^*|A_2\rangle|E_2\rangle$

(1) Ad hoc.

(2) Hard to make models Lorentz covariant.

(3) Tails have stories.


$\tau = 10^{15}$ sec $\simeq 10^{8}$ years.
$a = 10^{-5}$ cm
$l \gg a$
$l \ll a$
$\frac{1}{2} + \frac{1}{2}$
$\frac{3}{4}$
2
info Int
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