Title: Lecture - Quantum Foundations, PHYS 639

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Subject: Quantum Foundations

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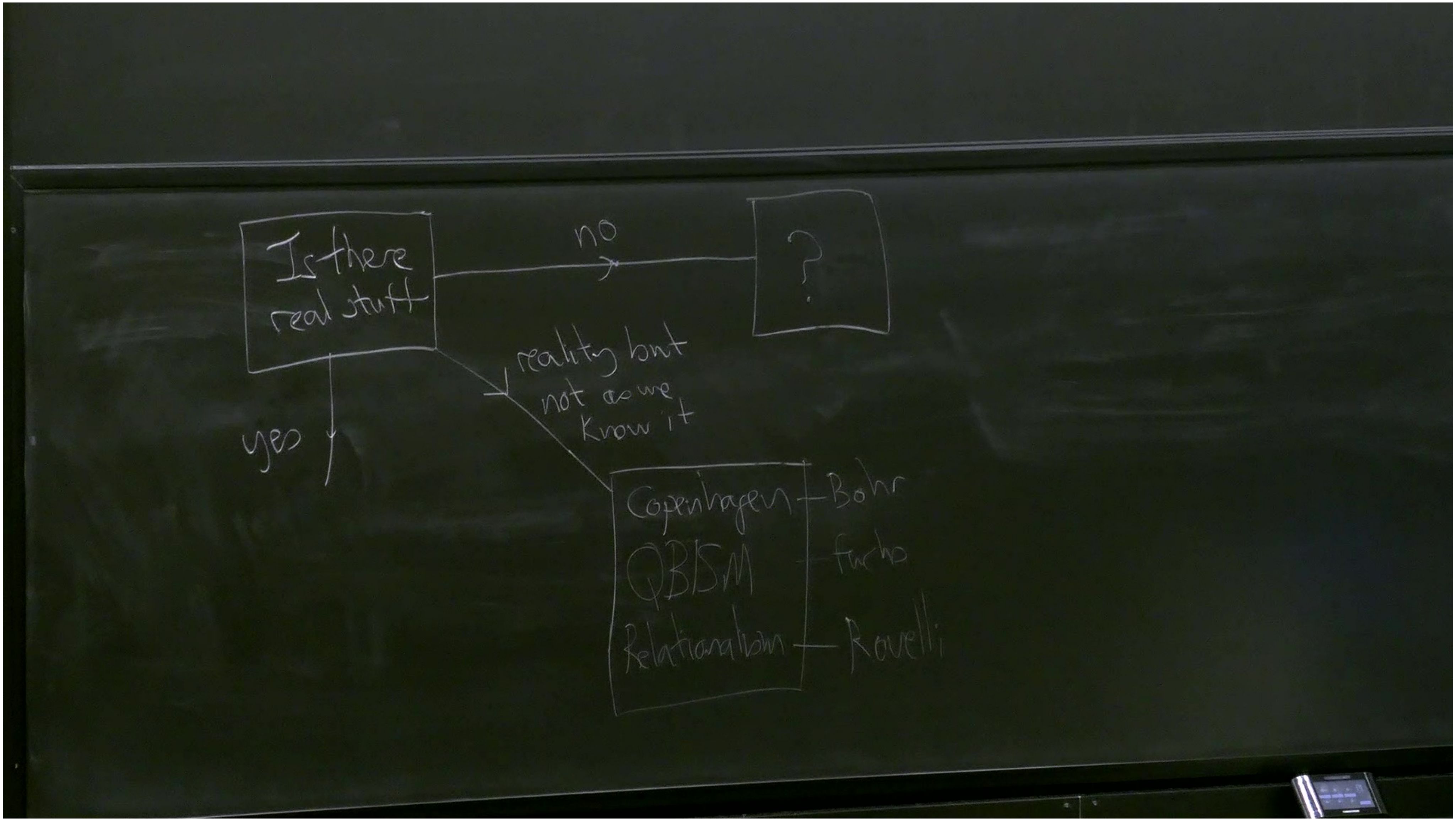
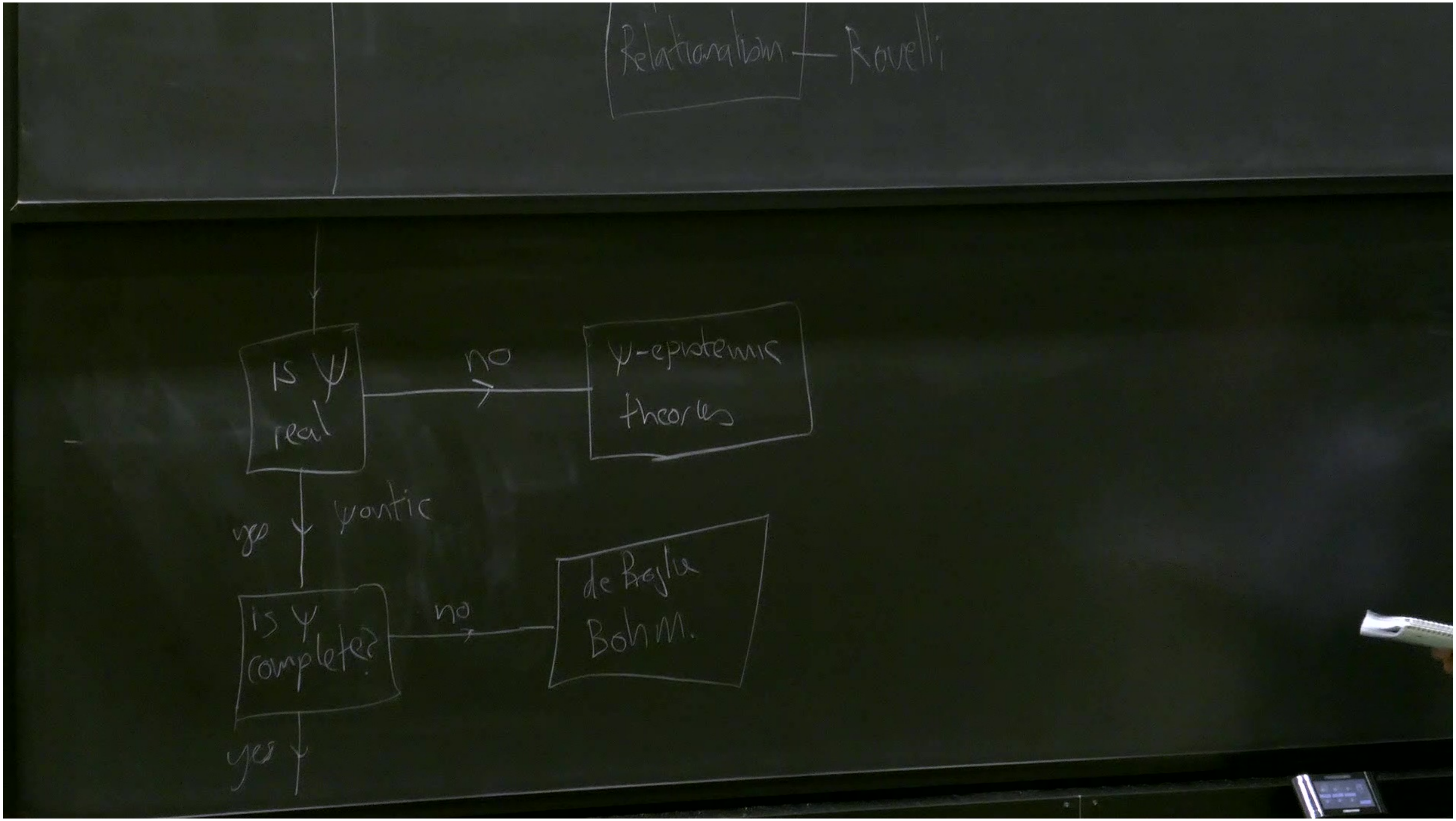
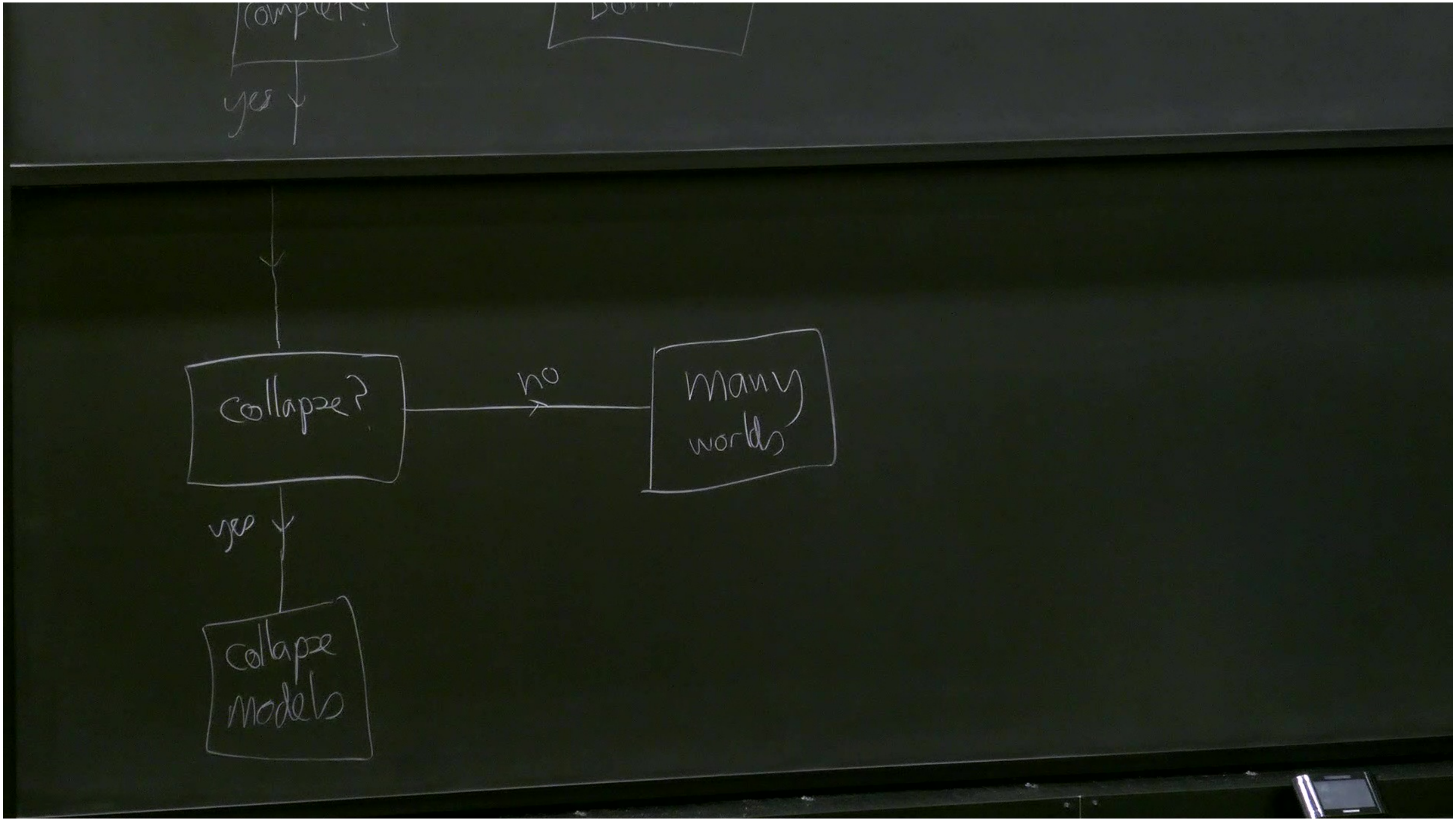
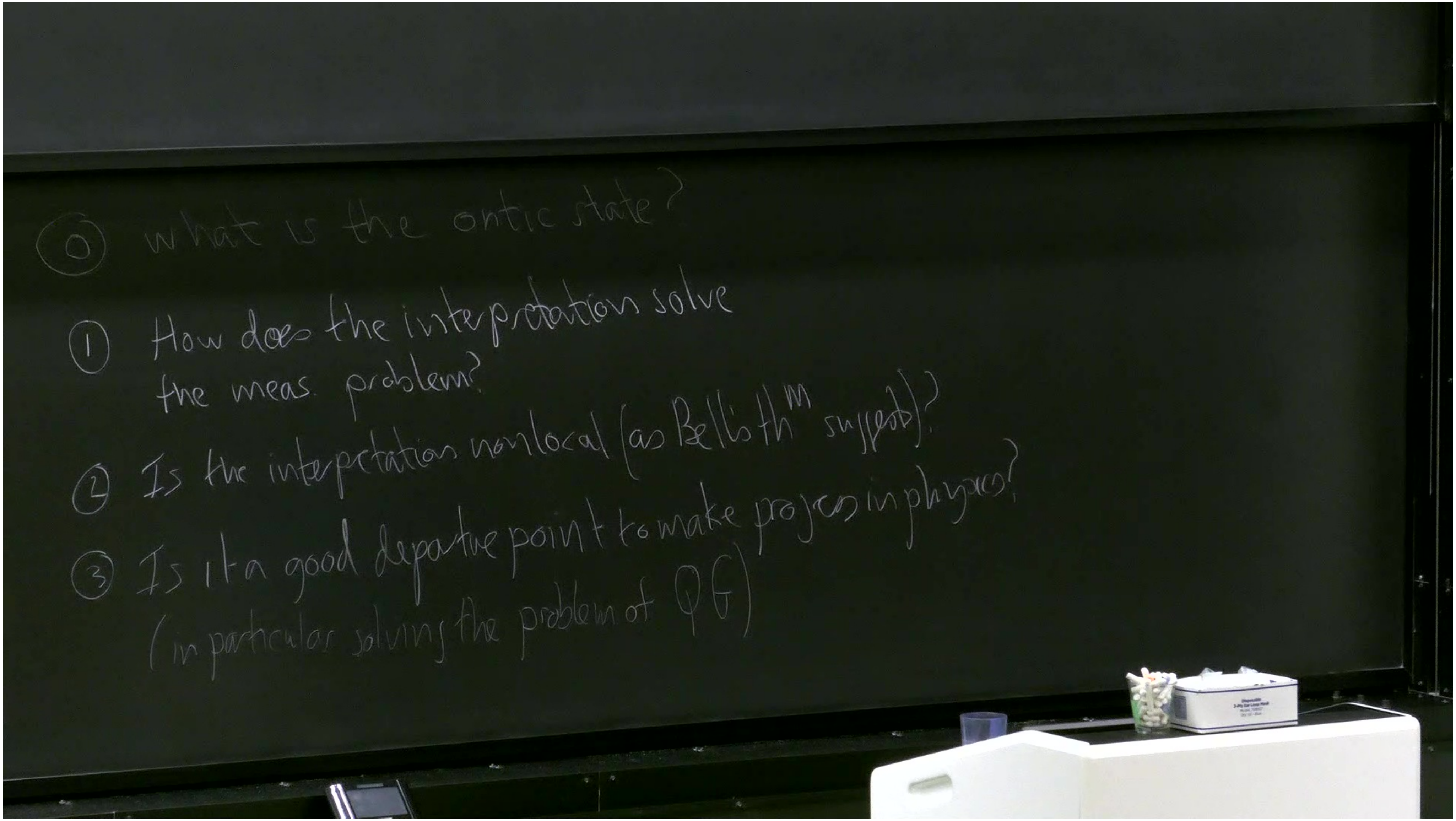

Is there real stuff
no
?
yes
reality but not as we know it
Copenhagen
QBISM
Relationalism
Bohr
Fuchs
Rovelli


Relationalism — Rovelli
is ψ real
no
ψ-epistemic theories
yes
ψ-ontic
is ψ complete?
no
de Broglie Bohm.
yes


yes
Collapse?
no
Many worlds
yes
Collapse models


0 what is the ontic state?
1 How does the interpretation solve
the meas. problem?
2 Is the interpretation nonlocal (as Bell's thm suggests)?
3 Is it a good departure point to make progress in physics?
(in particular solving the problem of QG)

The de Broglie Bohm model.

(1927) (1952)

Take care of non-rel. QM

$$\Psi(\vec{x}_1, \vec{x}_2, \dots \vec{x}_N, t)$$

evolves according to

$$i\hbar \frac{\partial \Psi}{\partial t} = \sum_{n=1}^{N} \frac{-\hbar^2}{2m} \nabla_n^2 \psi + V\psi$$

(0) The ontic state is

$$\left(\Psi(\vec{x}_1, \ldots \vec{x}_N, t), (\vec{X}_1, \ldots \vec{X}_N)\right)$$

put $x = (\vec{x}_1, \ldots \vec{x}_N)$, $X = (\vec{X}_1, \ldots \vec{X}_N)$

The dynamics is given by coupled eqns

(1) Schroedinger eqn

(2)

(0) The ontic state is

$$\left(\Psi(\vec{x}_1, \cdots \vec{x}_N, t), (\vec{X}_1, \cdots \vec{X}_N) \right)$$

put $x = (\vec{x}_1, \cdots \vec{x}_N)$, $X = (\vec{X}_1, \cdots \vec{X}_N)$

The dynamics is given by coupled eqns

(1) Schroedinger eqn

(2) Guidance eqn

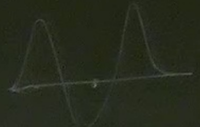
$$\frac{d\vec{X}_n}{dt} = \frac{\hbar}{M} \left. \frac{\mathrm{Im}(\psi^* \nabla_n \psi)}{\psi^* \psi} \right|_{x = X}$$

$$i\hbar\frac{\partial\psi}{\partial t} = \sum_{n=1} \frac{-\hbar^2}{2m}\nabla_n^2\psi + V\psi$$

Sometimes an additional assumption

③ At time $t=0$

$$\rho(\vec{x}_1, \dots \vec{x}_N, t=0) = |\psi(\vec{x}_1, \dots \vec{x}_N, t=0)|^2$$



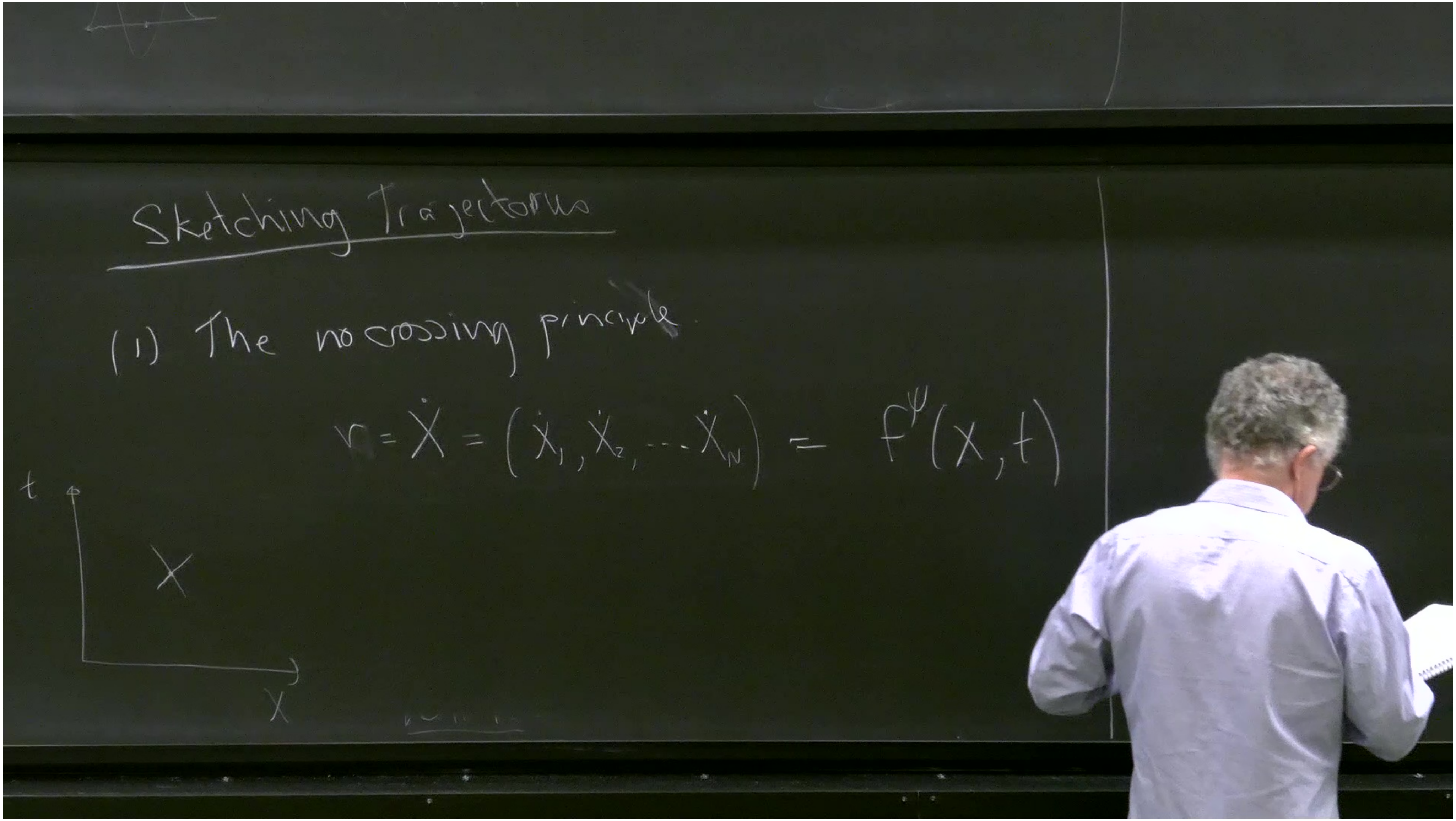
Valentini

If $\rho($

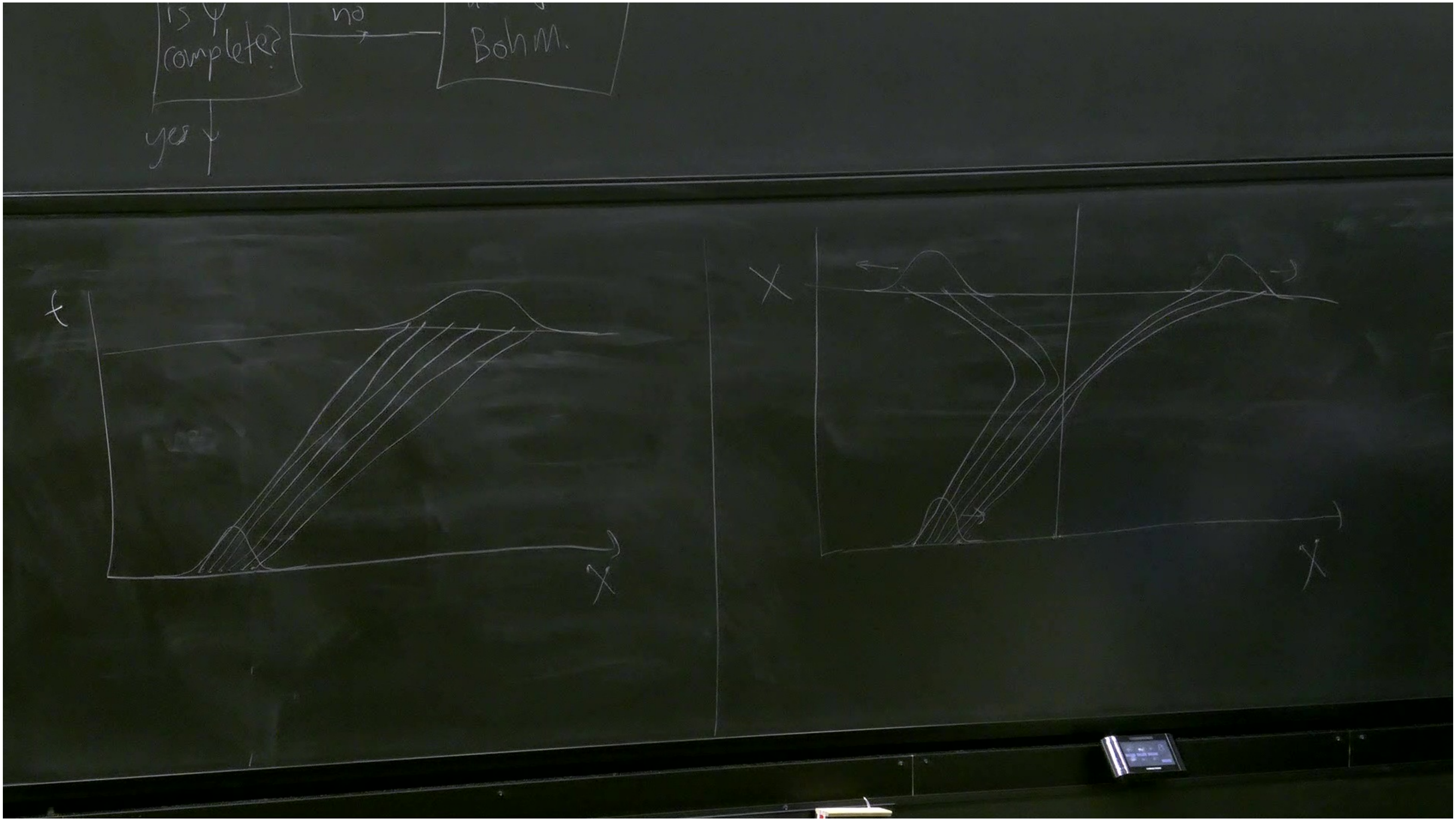
If $\rho(x, t=0) = |\psi(x, t=0)|^2$

then $\rho(x,t) = |\psi(x,t)|^2$ for later t.

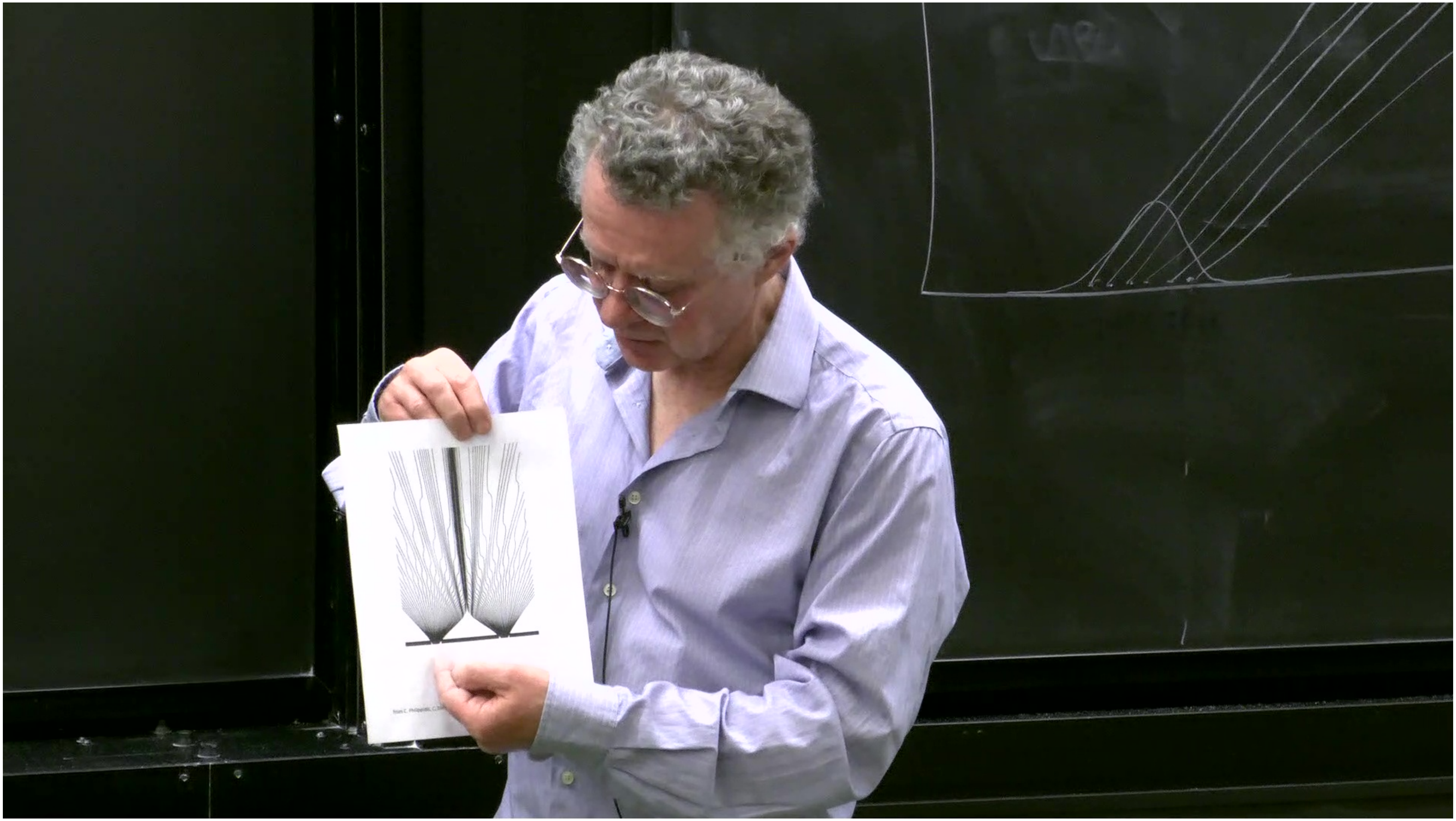
equivariance

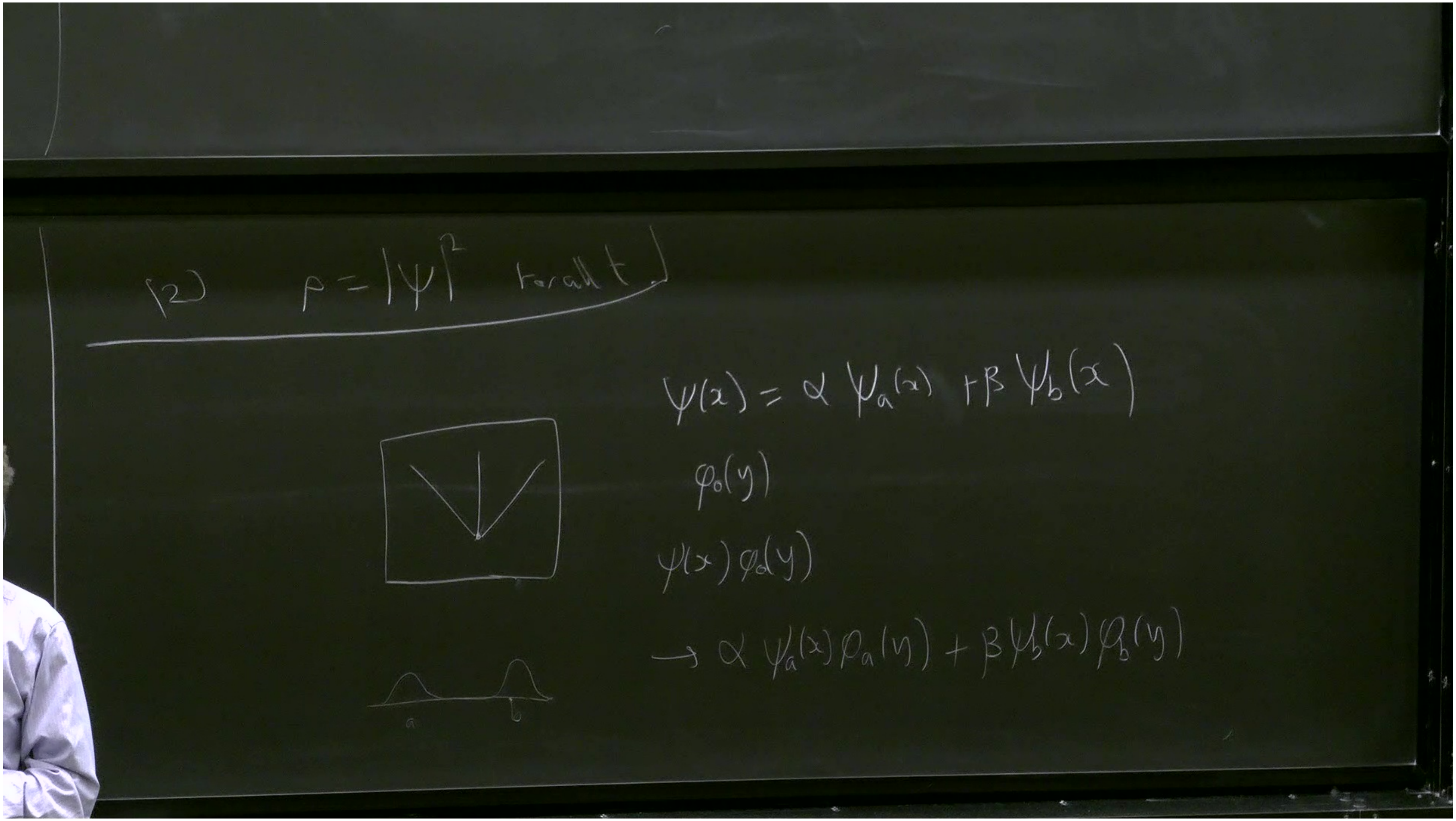

Sketching Trajectories
(1) The no crossing principle
$v = \dot{X} = (\dot{x}_1, \dot{x}_2, \ldots \dot{x}_N) = f^{\psi}(x,t)$
t
X
x

(2) $\rho = |\psi|^2$ for all t.



is ψ
complete?
no
Bohm.
yes
t
x
x
x




(2) $\rho = |\psi|^2$ for all t
$\psi(x) = \alpha\,\psi_a(x) + \beta\,\psi_b(x)$
$\varphi_0(y)$
$\psi(x)\,\varphi_0(y)$
$\to \alpha\,\psi_a(x)\,\varphi_a(y) + \beta\,\psi_b(x)\,\varphi_b(y)$
a
b