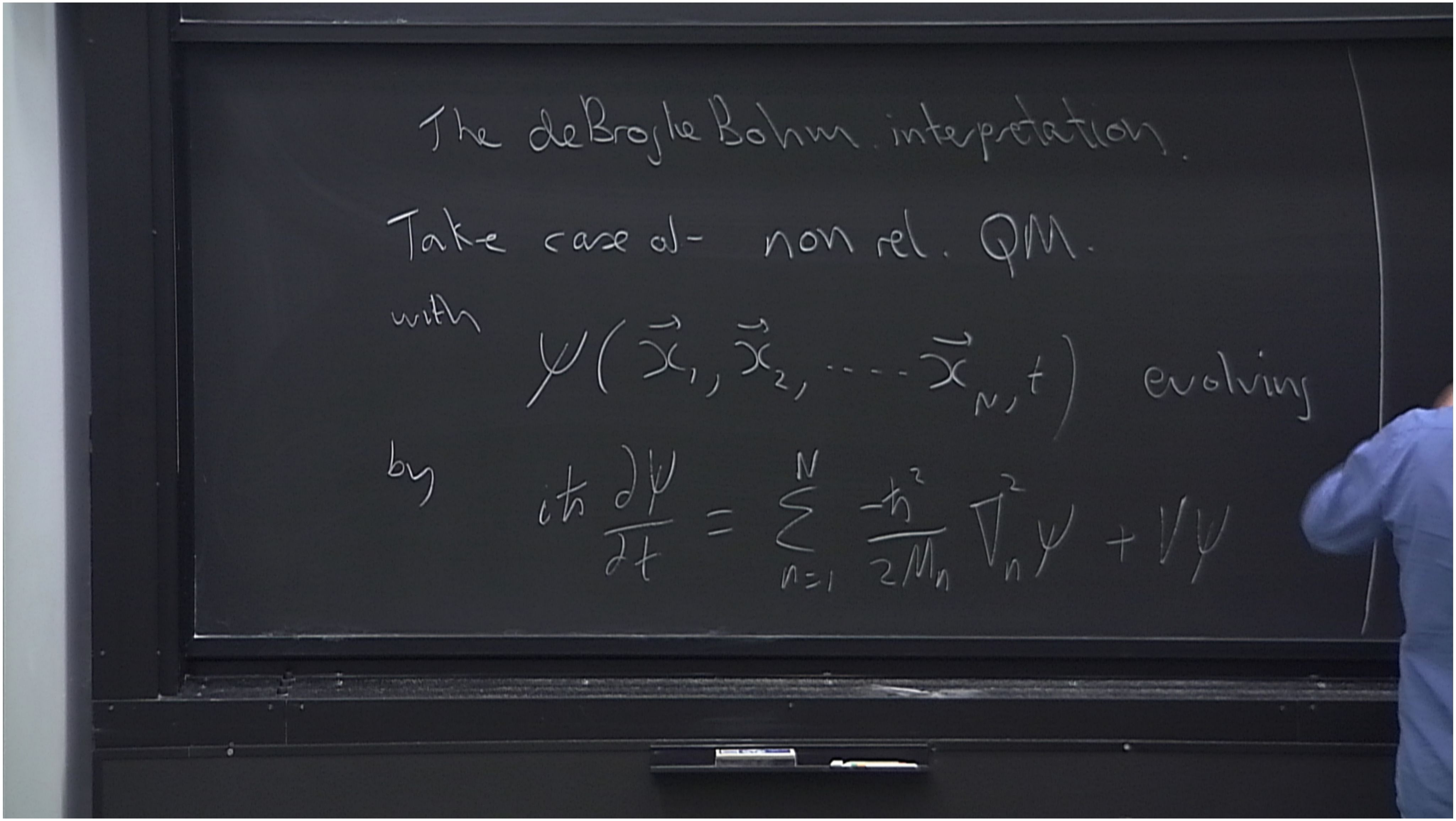
Title: PSI 2015/2016 Foundations of Quantum Mechanics - Lecture 6

Date: Jan 11, 2016 11:30 AM

URL: http://pirsa.org/16010059

Abstract:


The deBroglie Bohm interpretation.
Take case of non rel. QM.
with $\psi(\vec{x}_1, \vec{x}_2, \cdots \vec{x}_N, t)$ evolving
by $i\hbar \frac{\partial \psi}{\partial t} = \sum_{n=1}^{N} \frac{-\hbar^2}{2M_n} \nabla_n^2 \psi + V\psi$

volving

ψ

The ontic state at time t is

$$\Big(\psi(\vec{x}_1, \vec{x}_2, \dots \vec{x}_N, t), (\vec{X}_1, \vec{X}_2, \dots \vec{X}_N, t) \Big)$$

wave fn on config space

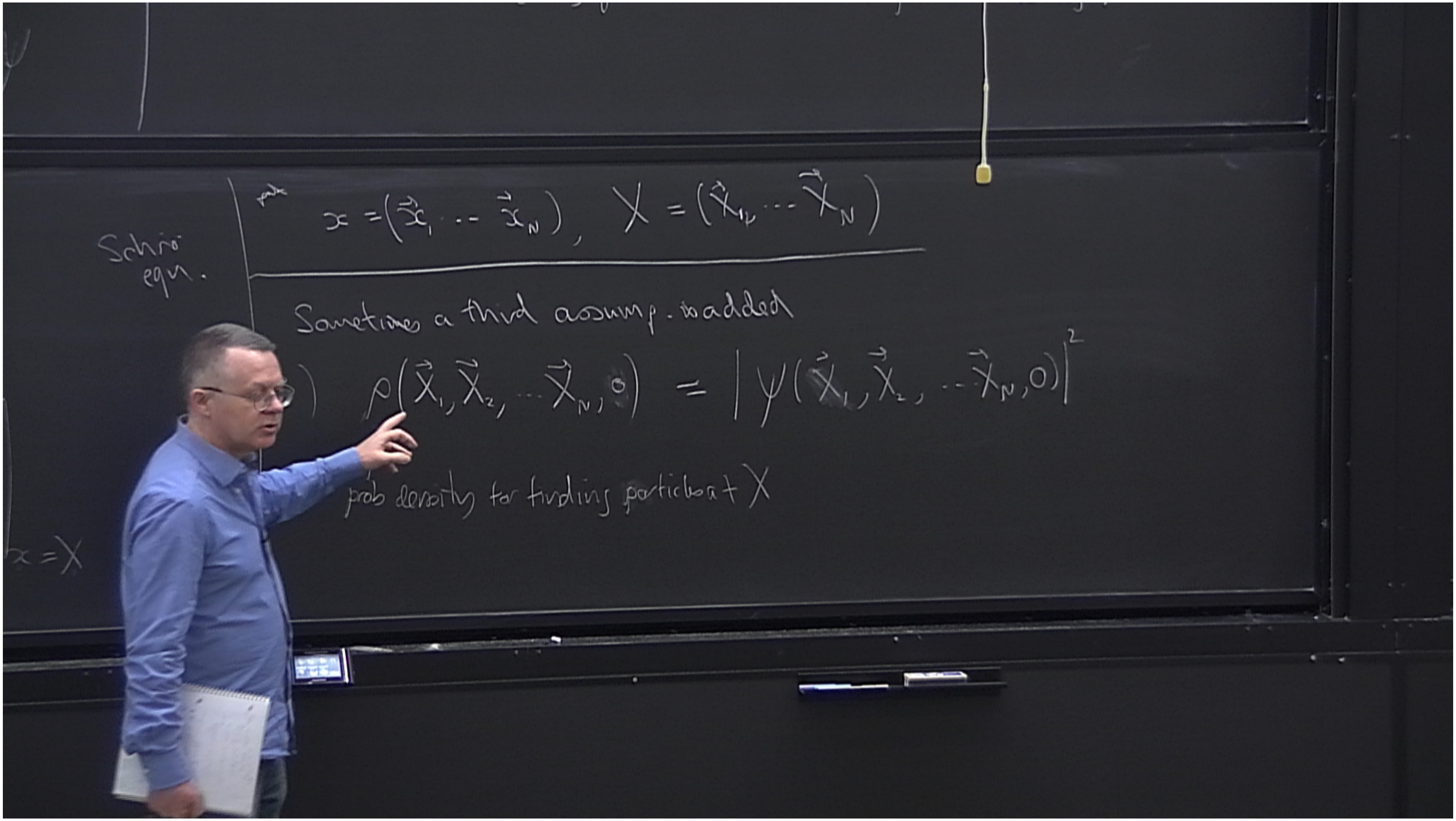
actual position in config space.

The dynamics is given by

1) $$i\hbar \frac{d\psi}{dt} = \sum_{n=1}^{N} \frac{-\hbar^2}{2m_n} \vec{\nabla}_n^2 \psi + V\psi$$

Schrö eqn.

2) $$\frac{d\vec{X}_n}{dt} = \frac{\hbar}{m_n} \frac{\mathrm{Im}(\psi^* \nabla_n \psi)}{\psi^* \psi}$$


Schrö eqn.
$x = (\vec{x}_1 \ldots \vec{x}_N), \quad X = (\vec{X}_1, \ldots \vec{X}_N)$
Sometimes a third assump. is added
$\rho(\vec{X}_1, \vec{X}_2, \ldots \vec{X}_N, 0) = |\psi(\vec{X}_1, \vec{X}_2, \ldots \vec{X}_N, 0)|^2$
prob density for finding particle at X
$x = X$

Schrö eqn.

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

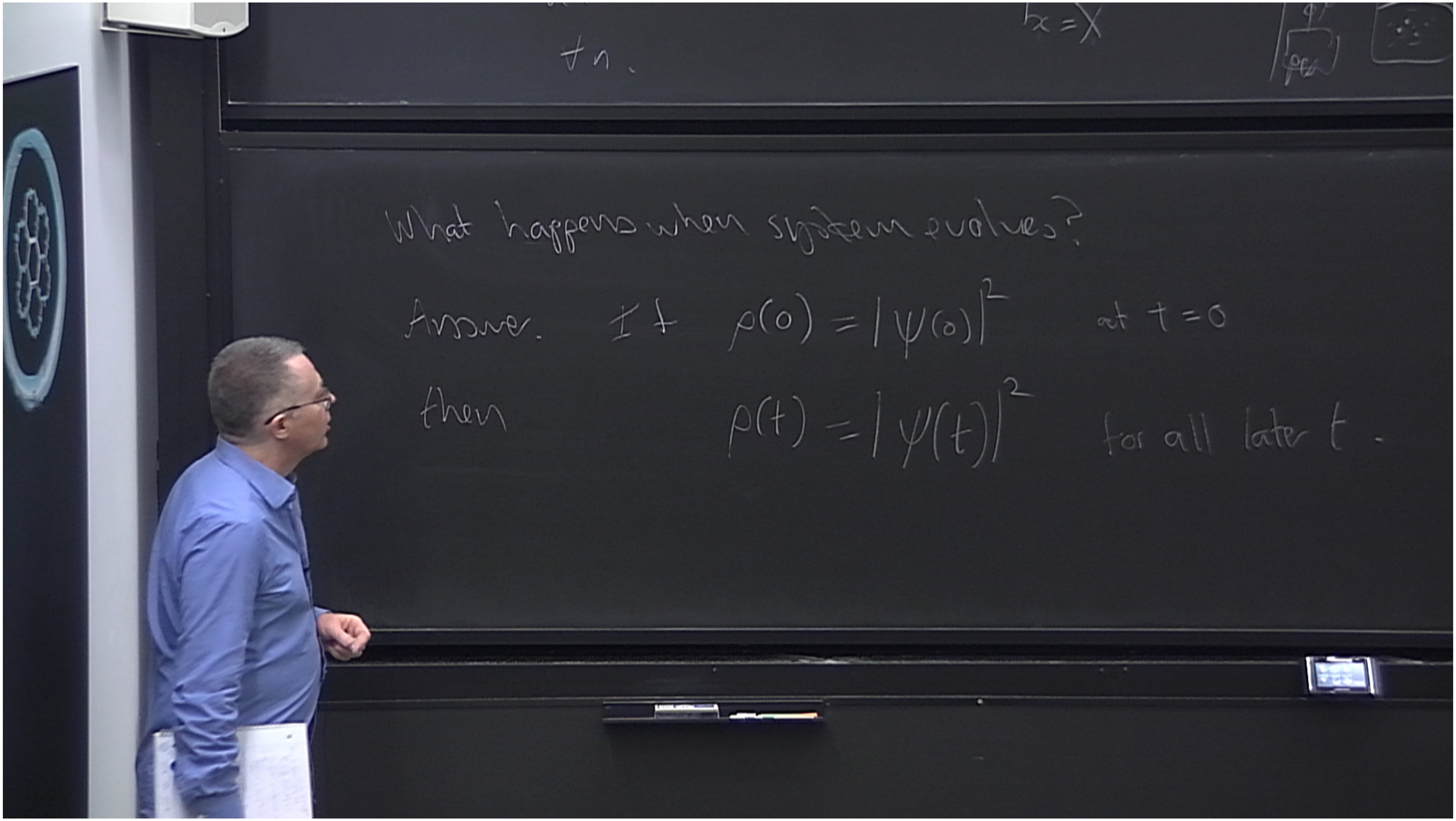
Sometimes a third assump. is added

3) $\rho(\vec{X}_1, \vec{X}_2, \dots \vec{X}_N, 0) = |\psi(\vec{X}_1, \vec{X}_2, \dots \vec{X}_N, 0)|^2$

prob density for finding particle at X

$= X$

q, ψ


What happens when system evolves?
Answer. If $\rho(0) = |\psi(0)|^2$ at $t=0$
then $\rho(t) = |\psi(t)|^2$ for all later t.

$\forall n$.

What happens when system evolves?

Answer. If $\rho(0) = |\psi(0)|^2$ at $t = 0$

then $\rho(t) = |\psi(t)|^2$ for all later t. quantum equilibrium.

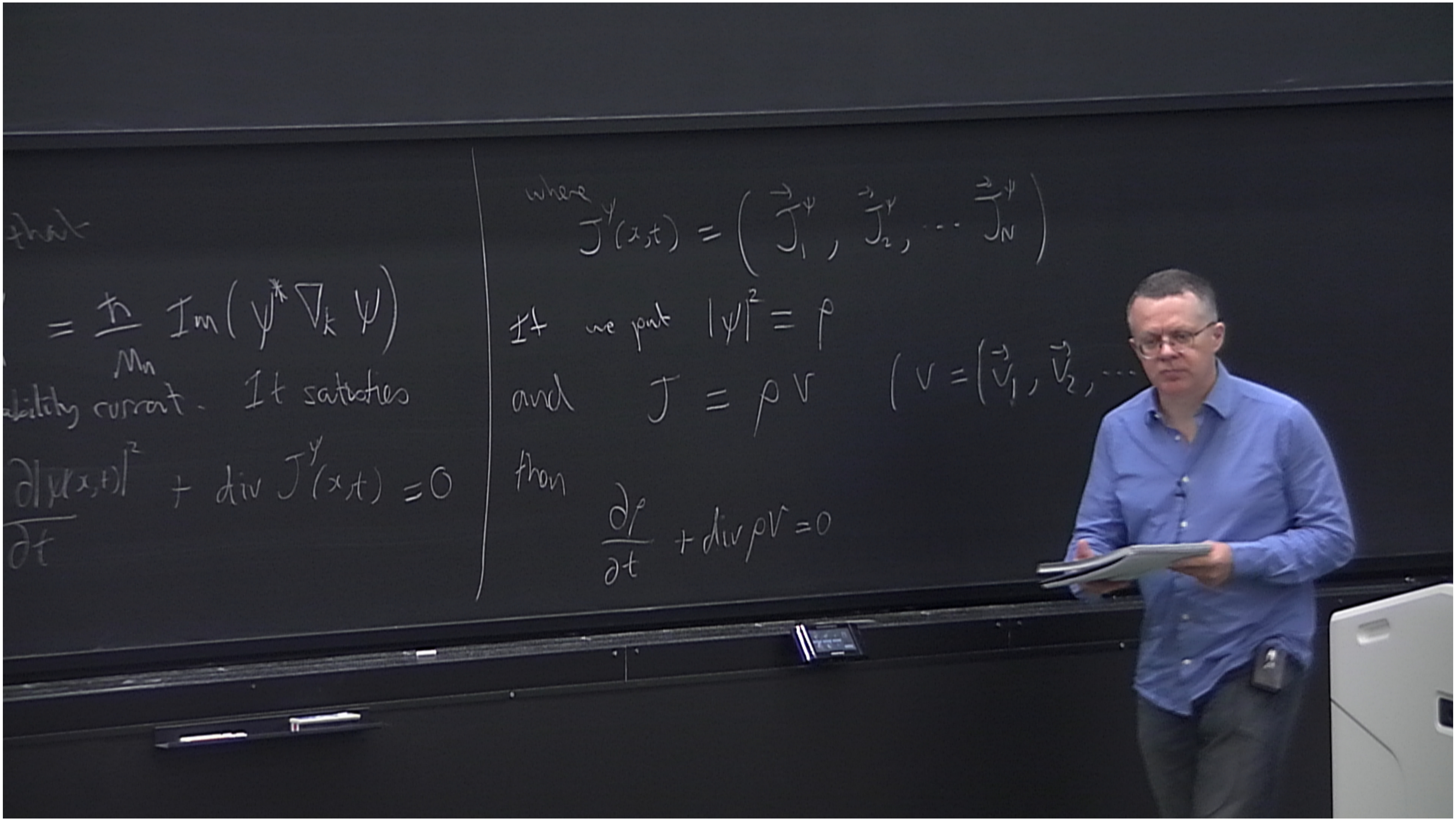
this property is called equivariance. Valentini.

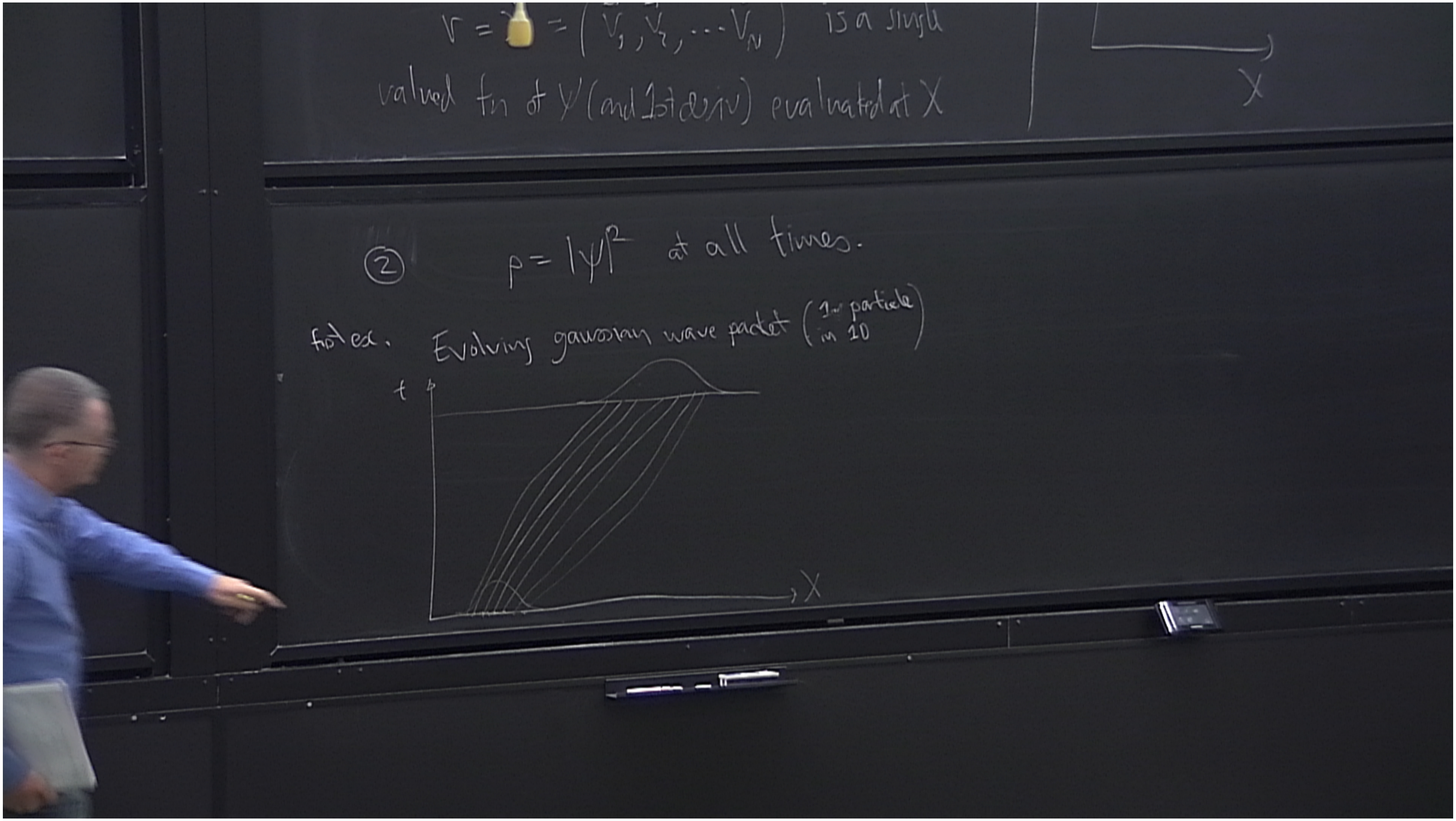
Note that

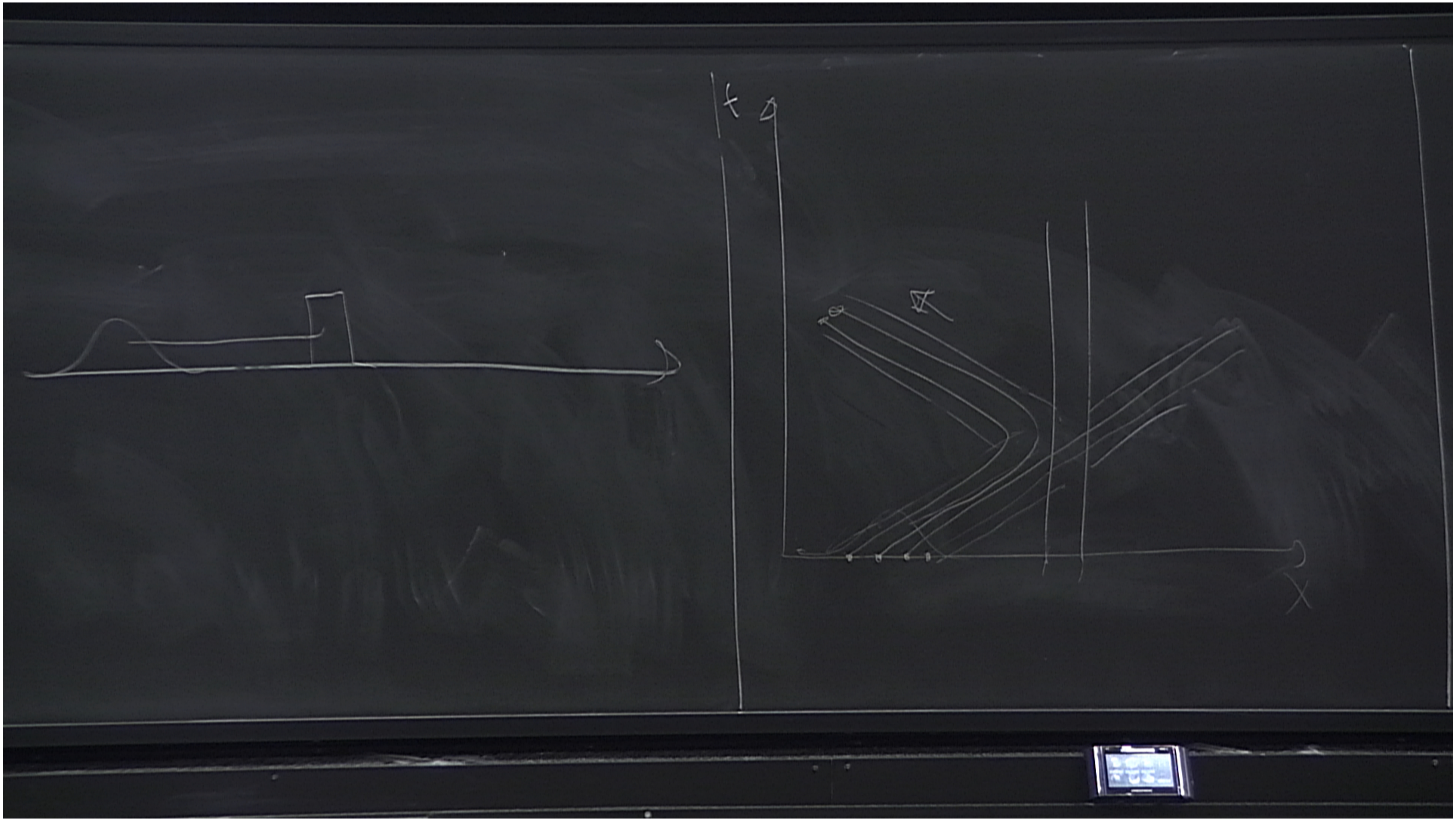
$$\vec{J}^{\psi}_{n} = \frac{\hbar}{m_n} \, \mathrm{Im}\left(\psi^* \nabla_k \psi \right)$$

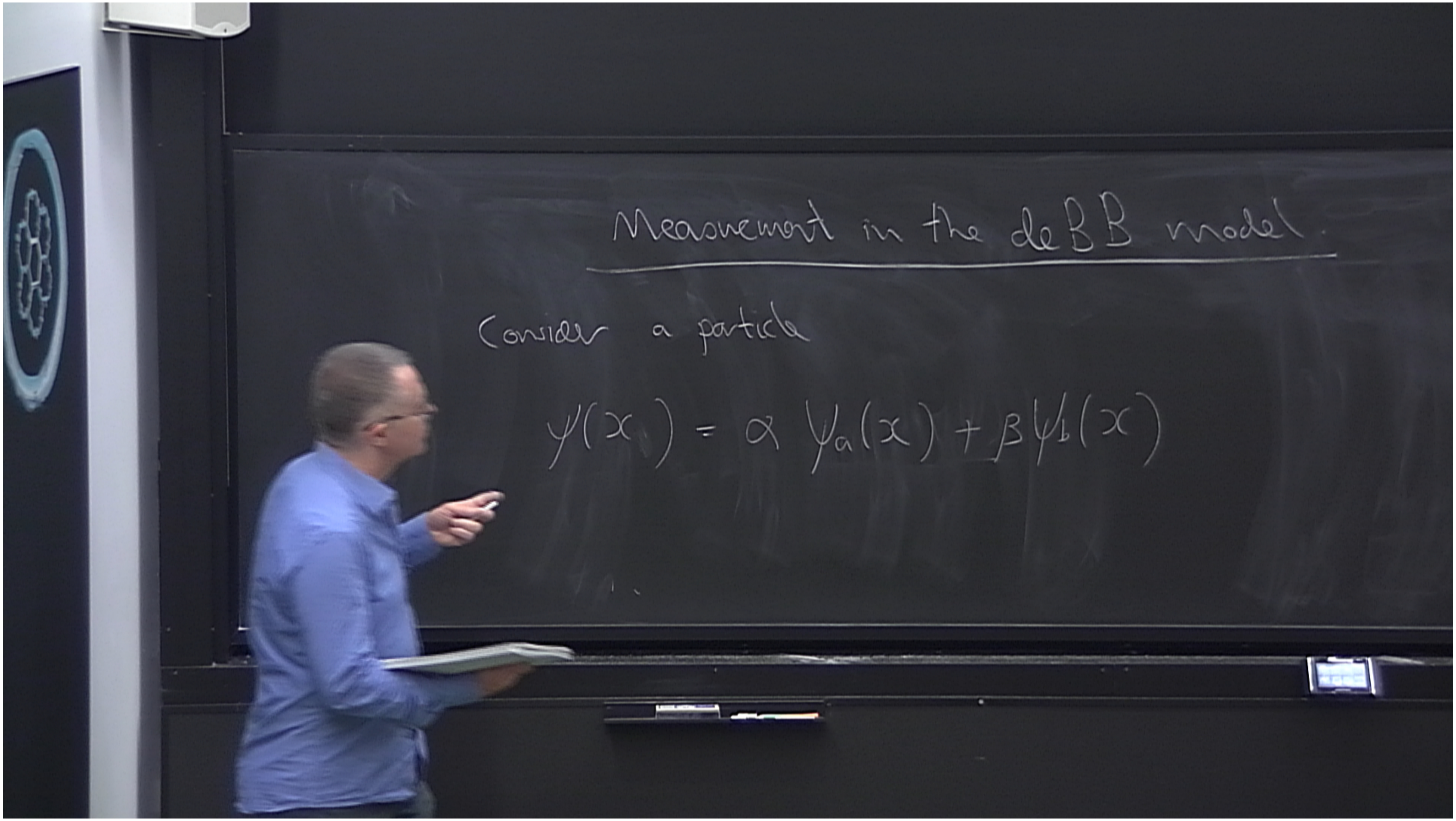
probability current. It satisfies

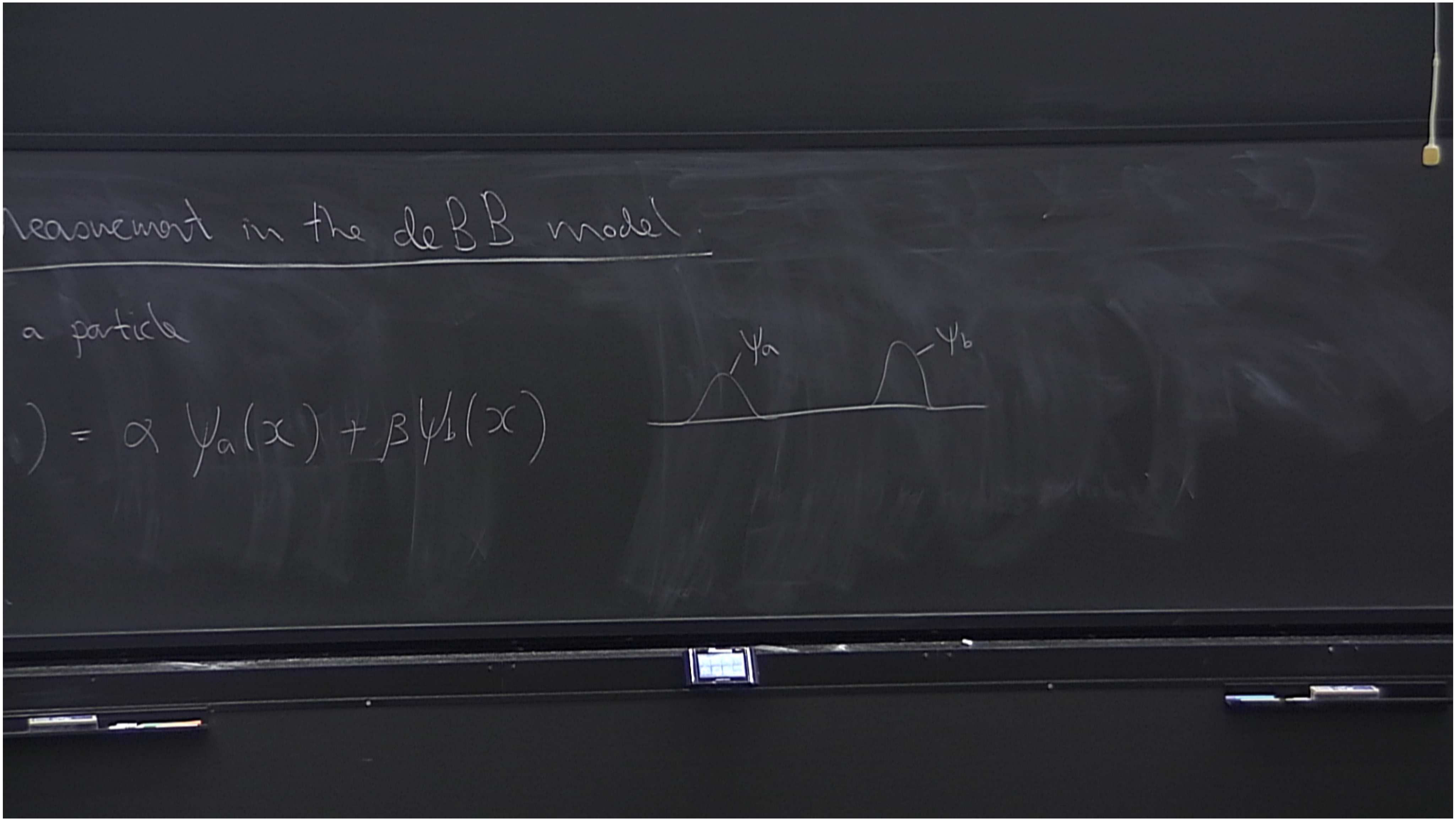
$$\frac{\partial |\psi(x,t)|^2}{\partial t} + \mathrm{div}\, J^{\psi}(x,t) = 0$$


that
$= \frac{\hbar}{m_n} \mathrm{Im}(\psi^* \nabla_k \psi)$
ability current. It satisfies
$\frac{\partial|\psi(x,t)|^2}{\partial t} + \mathrm{div}\, J^\psi(x,t) = 0$
where $J^\psi(x,t) = (\vec{J}_1^\psi, \vec{J}_2^\psi, \dots \vec{J}_N^\psi)$
If we put $|\psi|^2 = \rho$
and $J = \rho v$ $(v = (\vec{v}_1, \vec{v}_2, \dots$
then
$\frac{\partial\rho}{\partial t} + \mathrm{div}\, \rho v = 0$


v = = (V_1, V_2, ... V_N) is a single
valued fn of ψ (and 1st deriv) evaluated at X
X
② ρ = |ψ|^2 at all times.
for ex. Evolving gaussian wave packet (1 particle in 1D)
t
X

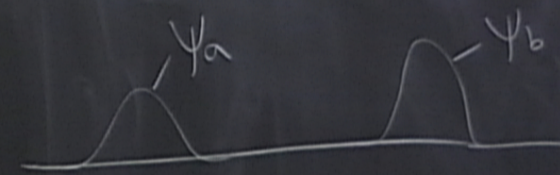

t
x


Measurement in the deBB model
Consider a particle
$\psi(x) = \alpha \psi_a(x) + \beta \psi_b(x)$


easurement in the deBB model.
a particle
$) = \alpha \psi_a(x) + \beta \psi_b(x)$
ψ_a
ψ_b

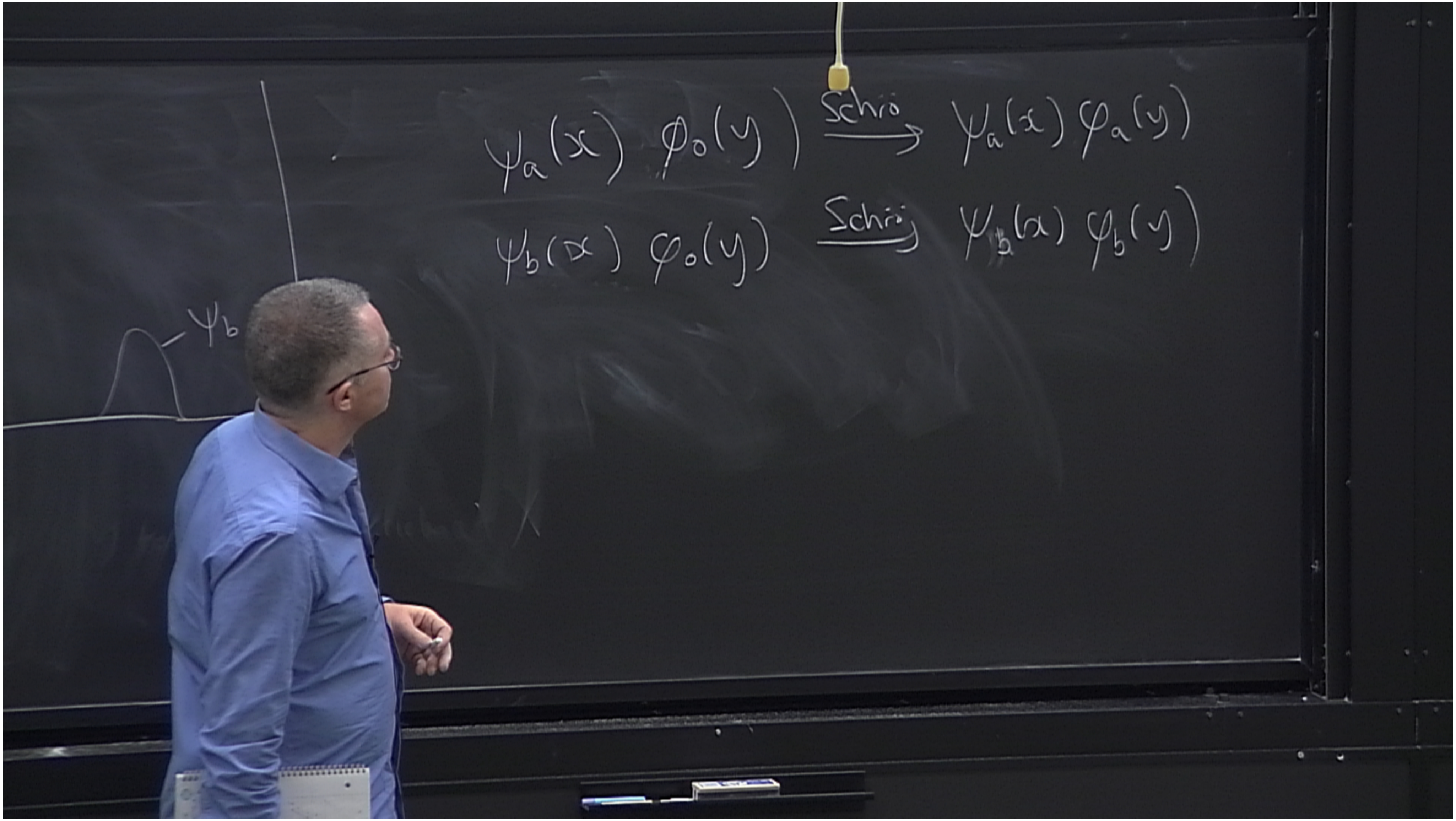
Measurement in the deBB model.

Consider a particle

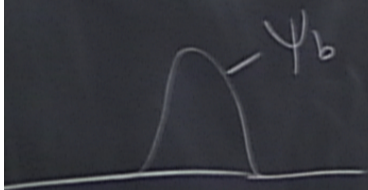


$$\psi(x) = \alpha\,\psi_a(x) + \beta\,\psi_b(x)$$

Introduce meas apparatus with pointer (y) s.t.



$\psi_a(x)\ \phi_0(y) \xrightarrow{\text{Schrö}} \psi_a(x)\ \varphi_a(y)$
$\psi_b(x)\ \varphi_0(y) \xrightarrow{\text{Schrö}} \psi_b(x)\ \varphi_b(y)$
ψ_b



$$\psi_a(x)\,\phi_0(y) \xrightarrow{\text{Schrö}} \psi_a(x)\,\varphi_a(y)$$

$$\psi_b(x)\,\varphi_0(y) \xrightarrow{\text{Schrö}} \psi_b(x)\,\varphi_b(y)$$

$$\psi(x)\,\varphi_0(y)$$

$$\longrightarrow \alpha\,\psi_a(x)\,\varphi_a(y) + \beta\,\psi_b(x)\,\varphi_b(y)$$