Title: Quantum Foundations Lecture

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Collection: Quantum Foundations

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Some questions about any given intepretation.

(0) What is the ontic state?

(1) How does the intepretation solve the measurement problem?

(2) Is the interpetation nonlocal?

(3) Is the interpretation a good departure point for making progress in physics (e.g. solving the problem of Quantum Gravity)?

The deBroglie Bohm model.
(1927) (1952)

Take non-relativistic QM with

$\psi(\vec{x}_1, \vec{x}_2, \ldots \vec{x}_N, t)$ evolves according to

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

$\vec{x}_i$ is a vector in 3 space.

(0) The ontic state at time t is

$$\left(\psi(\vec{x}_1, \vec{x}_2, \ldots \vec{x}_N, t), (\vec{X}_1, \vec{X}_2, \ldots \vec{X}_N) \right)$$

wave fn.

actual positions at actual particles.

$$x = (\vec{x}_1, \vec{x}_2, \ldots \vec{x}_N), \quad X = (\vec{X}_1, \vec{X}_2, \ldots \vec{X}_N)$$

The dynamics is given by the coupled eqns

(1) $$i\hbar \frac{\partial \psi}{\partial t} = \sum_{n=1}^{N} -\frac{\hbar^2}{m_n} \nabla_n^2 \psi + V\psi$$ Schrö eqn

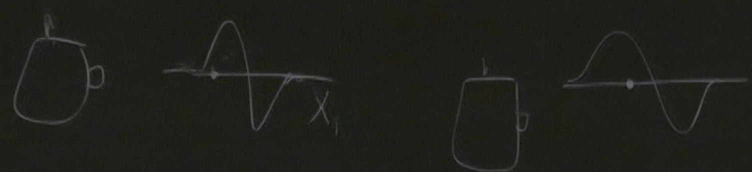
(2) $$\frac{d\vec{X}_n}{dt} = \frac{\hbar}{m_n} \frac{\mathrm{Im}(\psi^* \nabla_n \psi)}{\psi^* \psi}\Bigg|_{x=X}$$ guidence eqn.

Sometimes an additional postulate is added.

(3) At time $t=0$

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

Valentini



What happens when we evolve?

If $\rho = |\psi|^2$ at $t=0$

then eqns (1) and (2) implie that

$$\rho = |\psi|^2 \text{ for all later times.}$$

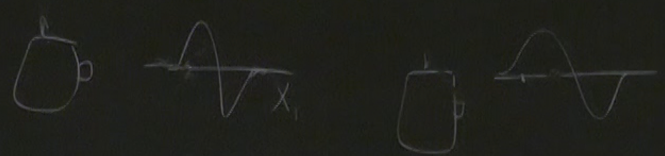
This property is called equivariance.

$\rho = |\psi|^2$ is called equilibrium.

Sometimes an additional postulate is added.

(3) At time $t=0$

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



Valentini

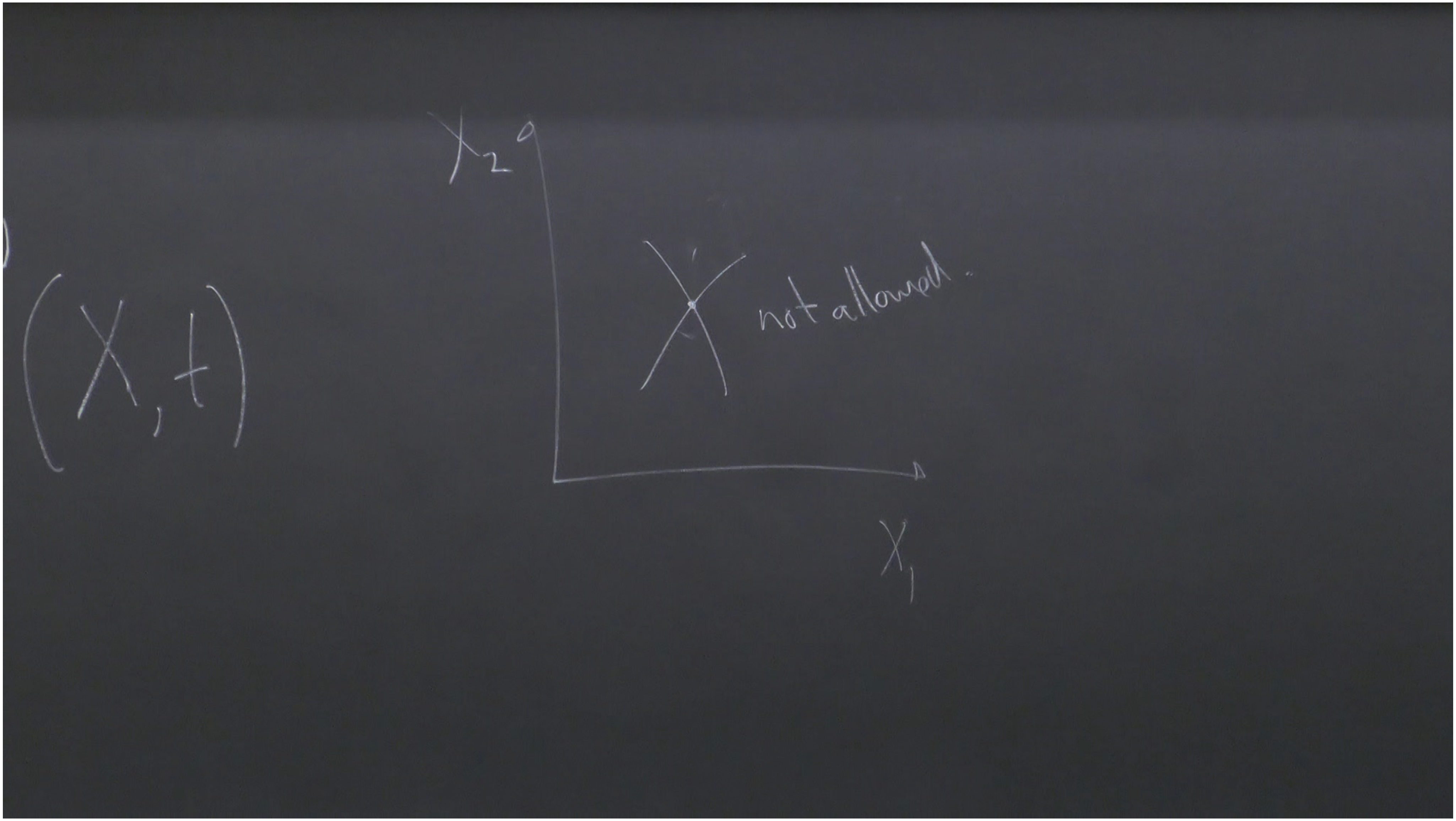
$$\vec{J}_n^{\psi} = \frac{\hbar}{m_n} \mathrm{Im}(\psi^* \nabla_n \psi)$$

Sketching deBB trajectories.

(1) The no crossing principle.

$$\dot{X} = \left(\dot{\vec{X}}_1, \dot{\vec{X}}_2, \ldots \dot{\vec{X}}_N\right) = f^{\psi}(X,t)$$

no crossing in configuration space.


(X, t)
X2
not allowed.
X1

(2) $\rho = |\psi|^2$ at all times.