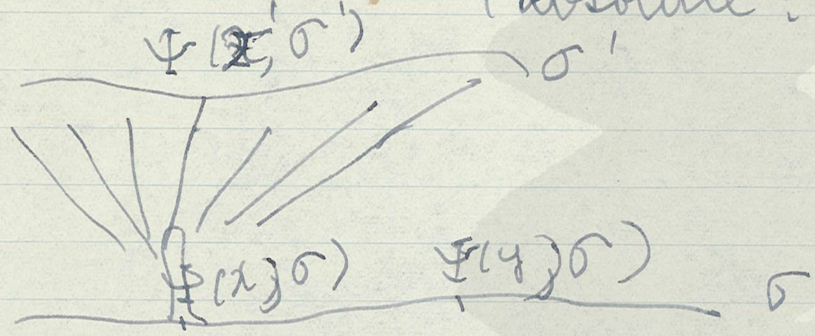
Dichotomy of Probability Concept

$\left\{ \begin{array}{l} \text{transition probability (amplitude)} \\ \quad\text{(relative to ?)} \\ \text{probability distribution (amplitude)} \\ \quad\text{(absolute ?)} \end{array} \right.$



$$\Psi(x',\sigma') = \int_\sigma U(x',\sigma'|x,\sigma)\,\Psi(x,\sigma)\,d^3x$$

$\downarrow$ t.p.a. $\qquad \downarrow$ p.d.a.

$$\left\{ \begin{array}{l} \sigma \to \sigma' \\ \Psi(x,\sigma) \to \delta_\sigma(x) \end{array} \right.$$

$$\Psi(x,\sigma) = \int \Psi(x,\tau)\,\delta(\sigma,\tau)\,d\tau$$

$$\Psi(x',\sigma') = \int U(x',\sigma'|x,\tau)\,\Psi(x,\tau)\,\delta(\sigma,\tau)\,d\tau\,d^3x$$

$$V(x',\sigma'|x,\sigma) = U(x',\sigma'|x,\tau)\,\delta(\sigma,\tau)$$

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Second Quantization

I. Non-relativistic theory

$$\left.\begin{aligned} i\hbar\frac{\partial\psi}{\partial t} &= H\psi \\ -i\hbar\frac{\partial\psi^*}{\partial t} &= \psi^* H \end{aligned}\right\} \quad \psi(x,y,z,t)$$

(C) $$[\psi(x,t),\ \psi^{\dagger}(x',t)] = i\hbar\,\delta^3(x-x')$$

$$L = \psi^*\left(i\hbar\frac{\partial\psi}{\partial t} - H\psi\right)$$

$$\psi^{\dagger} = i\hbar\,\psi^*$$

$$[\psi(x,t),\ \psi^*(x',t)] = \delta^3(x-x')$$

$$\rho(x,t) = \psi^*(x,t)\,\psi(x,t)$$

$$[\psi(x,t),\ \rho(x',t)] = [\psi(x,t),\psi^*(x',t)]\,\psi(x',t) + \psi^*(x',t)\,[\psi(x,t),\psi(x',t)]$$

$$= \delta^3(x-x')\,\psi(x',t)$$

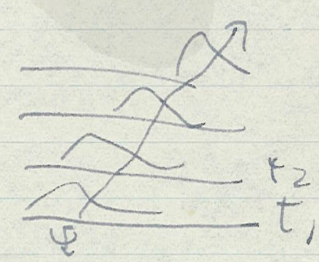
$$\psi(x,t)\cdot\rho(x',t) = \{\rho(x',t) + \delta^3(x-x')\}\,\psi(x,t)$$

~~$\Psi(\{\rho(x)\},t)$~~

$$\bar{H} = \int \psi^* H \psi\, d^3x$$

(M) $$i\hbar\frac{\partial\psi}{\partial t} = [\psi,\ \bar{H}] = H\psi$$

$$i\hbar\frac{\partial}{\partial t}\Psi(\{\rho(x)\},t) = \bar{H}\,\Psi$$



$$\Psi(\{\rho(x)\},t_1) \rightarrow \Psi(\{\rho(x)\},t_2) \rightarrow \cdots$$

$$\bar{F}\,\Psi(\{\rho(x,t)\}) = 0$$

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$$\Psi(\{\rho(x)\}, t+\Delta t) = \Psi(\{\rho(x, t+\Delta t)\})$$

$$i\hbar \frac{\Delta\Psi}{\Delta t} = i\hbar \; \frac{\Psi(\{\rho(x, t+\Delta t)\}) - \Psi(\{\rho(x,t)\})}{}$$

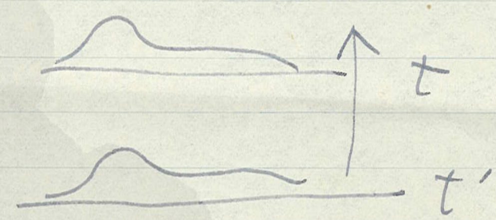
$$\Psi(\{\rho(x,t)\}) = e^{-i\bar{H}(t-t')\frac{\Delta t}{\hbar}} \Psi(\{\rho(x, t')\})$$

$$e^{i\bar{H}t} \Psi(\{\rho(x,t)\}) = e^{i\bar{H}t'} \Psi(\{\rho(x,t')\})$$

$$\parallel$$

$$\Phi(\{\rho(x,t)\}) = \Phi(\{\rho(x,t')\})$$

stationary distribution



~~Momentum space~~:

~~$\psi(x,t)$~~

$[\psi, \bar{H}]$ = non-linear in ψ in general

$\bar{H} = \bar{H}_0 + \bar{H}'$

$i\hbar \frac{\partial\psi}{\partial t} = H_0 \psi$

(absolute))
probability amplitude → state vector → ambiguity
(by itself) → Hilbert space
probability amplitude
relative to something (like vacuum)
→ Feynman amplitude?

$$\overline{H} = \int \psi^* \frac{p^2}{2m} \psi \, d^3x + \frac{e^2}{2} \int\int \frac{\psi^*(x)\psi^*(x')\psi(x')\psi(x)}{|r-r'|} d^3x \, d^3x'$$