Chapter 5

Identical particles

lesson 42.1

* Indistinguishable particles :- particles which are hard to differentiate

two types of wave functions

$\psi(r)$: $\psi(r,t)$

$\psi(r_1, r_2)$ $\psi(r_1, r_2, t)$

$$\left[H = -\frac{\hbar^2}{2m}\nabla_1^2 - \frac{\hbar^2}{2m}\nabla_2^2 + V(r_1, r_2, t)\right]$$

* Hamiltonian wave function

$\therefore i\hbar \frac{\partial \psi}{\partial t} = H\psi$

$$\int_{-\infty}^{+\infty} |\psi|^2 dr = 1 \Rightarrow \int_{-\infty}^{+\infty} |\psi(r_1, r_2, t)|^2 d^3r_1, d^3r_2 = 1$$

any one axis x/y/z

all three x, y, z with time dependant

(*) IMPORTANT

$$\psi(\vec{r}_1, \vec{r}_2, t) = \psi(r_1, r_2)\, e^{-\frac{iEt}{\hbar}}$$

$\psi(r_1, r_2)$: space wave

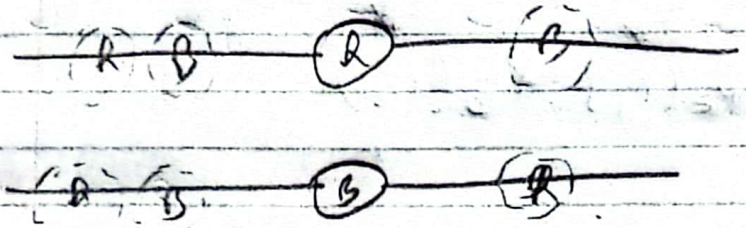
$e^{-\frac{iEt}{\hbar}}$: time component (time wave)

(*) $$-\frac{\hbar^2}{2m}\nabla_1^2\psi - \frac{\hbar^2}{2m}\nabla_2^2\psi + V\psi = E\psi$$

Two types of particles

(*) Bozons and Fermions

Classical mechanics

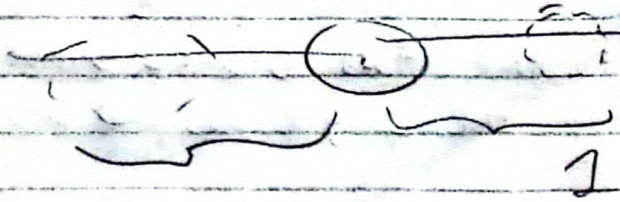


4 possibilities

Quantum

3 Possibi

same thing



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two electrons can't have the same state ⇒ not possible

stated

* Electrons can be ~~distinguished~~ through spin one is ↑ & the other ↓ but cannot be distinguished

* these are called indistinguishable particles

$$\psi_a(r) : \psi_b(r)$$

$$\psi(r_1, r_2) = \psi_a(r_1)\,\psi_b(r_2)$$

two states

particle 1 2

Singlet state $= \frac{1}{\sqrt{2}}\{\uparrow\downarrow - \downarrow\uparrow\}$

triplet state

we can't separate the two states since the "singlet state" it is one single coupled state