Lecture #2 The Wave Function

Basic Quantum Notion

Wavefunction ψ complex

$$\psi = \mathrm{Re}\,\psi + i\,\mathrm{Im}\,\psi$$
$$\psi^* = \mathrm{Re}\,\psi - i\,\mathrm{Im}\,\psi$$
$$\psi^*\psi = |\psi|^2 = \mathrm{Re}\,\psi^2 + \mathrm{Im}\,\psi^2 \geq 0$$

Wave function is prob. amplitude

How to teach QM?
We will just jump right in

What does QM mean?

Time evolution of classical system from Newton's laws

Time evolution of Quantum System from time dependent Schrodinger equation

See pages 5, 6, 7 from last lecture

Time evolution of classical system

Need inital conditions

$x(t=0)$ position

$p(t=0)$ momentum

Then integrate Newton's laws

$$F = -\frac{dV}{dx} = Ma = \frac{dp}{dt}$$

to get $x(t)$

$p(t)$

In principle if you know all of the forces and all of the inital conditions then you can predict all of the motions for all time.

For how long can we make predictions in practice?
Integrations have been run for longer then the age of the solar system ≥ 4.7 billion years

Is the classical world predetirmened?

Is everything fated? No because of chaos.

<u>Chaos</u>: extreme sensitivity to inital conditions. Change one inital condition by a very small amount and the outcome may be very different

It is hard to forcast the long term weather because of chaos.

In QM ability to predict far in future is limited because of uncertianty principle. Indeed ability to make predictions for even right now is limited.

* What are <u>Quantum inital conditions</u>? Cant be both $x(t=0)$ and $p(t=0)$.

Instead need wavefunction $\Psi(x, t=0)$ for all x.

What takes place of Newton's 2^{nd} law? Integrate time dependent Schrodinger equation to get

$$\Psi(x, t > 0)$$

$$\boxed{i\hbar \frac{\partial \Psi(x,t)}{\partial t} = -\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2} \Psi(x,t) + V(x)\, \Psi(x,t)}$$

$V(x)$ = Pot. energy

$\hbar = \frac{h}{2\pi} = 1.05457 \times 10^{-34}$ J s

Planck's constant

m = mass of particle

$i = \sqrt{-1}$ QM is inher. complex

(a) I just told you this was the answer. Just like you were told $F = ma$

(b) later we will "derive" Schrodinger eq. or at least see how it is part of geneal frame work

(c) Keep track of partial derivatives
Ψ function of both x, t but
V assumed only function of x

(d) If we know $\Psi(x, t=0)$ then
we can integrate Schrodinger eq.
to find Ψ for all time.

(e) What does Ψ mean?