PHYSICS 248 Lecture 13 Gary Shiu

2/26/07

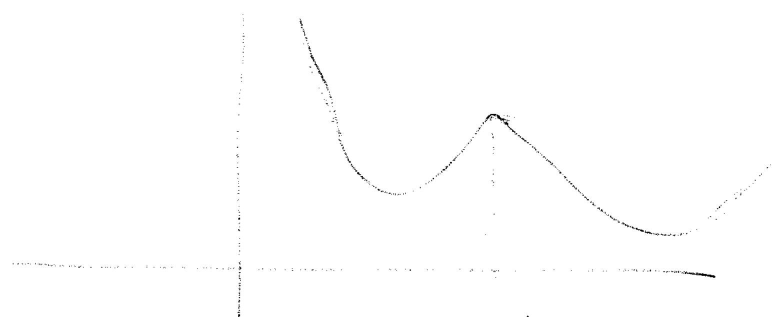
Davisson - Germer Experiment

D= atomic spacing ~ Å

$n\lambda = d\sin\theta$

Given E $\Rightarrow$ $\lambda = \frac{h}{\sqrt{2mE}}$

Scan θ



de Broglie relations

$$E = h\nu = \hbar\omega$$

$$p = \frac{h}{\lambda} = \hbar k$$

$\boxed{\text{Light}}$ $E = pc \Rightarrow \hbar\omega = \hbar k c$

$$\omega = ck$$

$$\boxed{\lambda\nu = c}$$

$\boxed{\text{Matter}}$ $E = \frac{p^2}{2m} \Rightarrow \hbar\omega = \frac{\hbar^2 k^2}{2m}$

$$\omega = \frac{\hbar k^2}{2m}$$

Particles can be interpreted as waves

$\Psi(\vec{r}, t)$ wave function

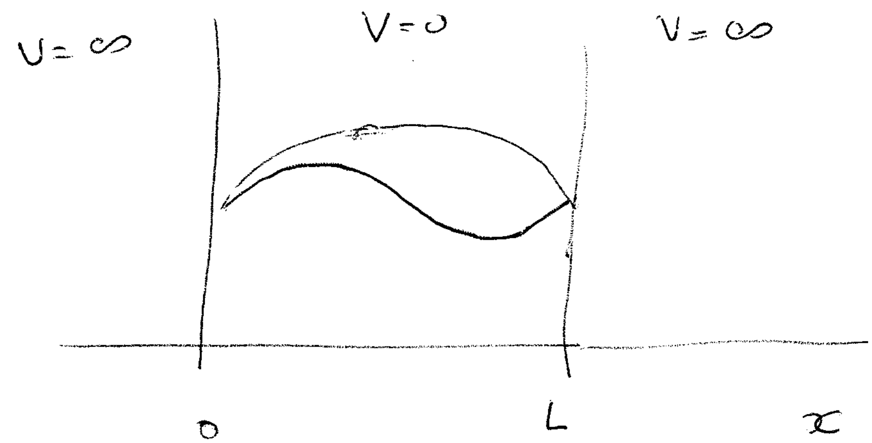
Just as the wave function of guitar strings $\Psi(\vec{r}, t)$ satisfies a wave equation.

What does $\Psi(\vec{r}, t)$ tell us?

Probability $\Rightarrow |\Psi(\vec{r}, t)|^2$

Particle in a box

Instead of considering standing waves for e^- in an atom, let's first consider particle in a box



Guess $\psi = \sin kx$ Standing wave

$\psi(0) = 0$ ✓

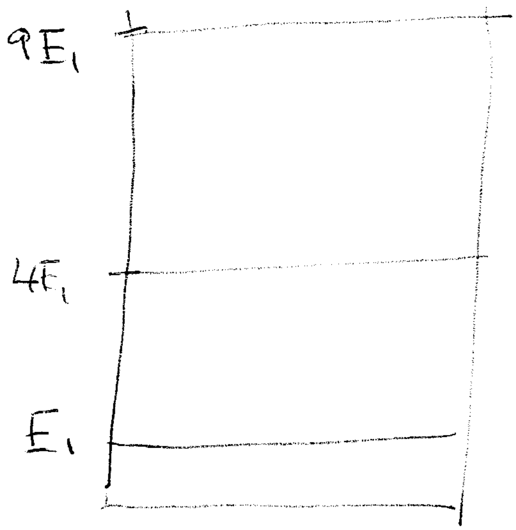
$\psi(L) = \sin kL = 0$

$\Rightarrow k = \frac{n\pi}{L}$

$\Rightarrow \boxed{\lambda = \frac{nL}{2}}$ Exactly half integer multiple of λ must fit in the box

$$E = \frac{p^2}{2m} = \frac{\hbar^2 k^2}{2m}$$

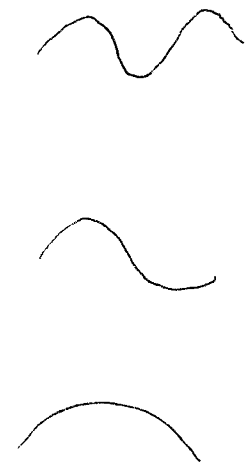
$$= \frac{\hbar^2}{2m}\left(\frac{n\pi}{L}\right)^2$$ energy is quantized



$\psi = \sin \frac{3\pi x}{L}$

$\psi = \sin \frac{2\pi}{L} x$

$\psi = \sin \frac{\pi}{L} x$



Lowest energy level

$$E_1 = \frac{\pi^2 \hbar^2}{2mL^2} \qquad \text{zero point energy}$$

Note n cannot be zero $\because \psi = 0$

Even at zero temperature, when particle like to occupy E_1 state, still kinetic energy

$$E_1 = \frac{\pi^2 \hbar^2}{2mL^2}$$

Q: How does a particle go from one quantum state to another?

A: Bohr suggested $h\nu_{mn} = \underbrace{E_m - E_n}_{\text{energy level of quantum system}}$

light frequency