de Broglie, Heisenberg, Schrodinger, and others

Note Title 11-01-2011

Administrative business

1(a) Quiz on Thursday Jan. 17, 2011

1(b) Venue: Exh. hall, WS204, 209, 213

1(c) Time: After 5 pm (TBA)

1(d) Syllabus: Chapter 8 of Atkins

2(a) Tutorial sheet I available on the webpage and in SCOOPS.

2(b) You will be marked absent if you come to the tutorial class without the tutorial sheet.

COBE satellite

NASA (blackbody)

Big - Bang theory

3K

George Smoot &

John Mather 2006

Nobel prize

"Count" de Broglie (1924)

photon, zero rest mass: $E = pc$ & $E = h\nu$

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

material particles

$v > c$ → group velocity was not greater than c

Davisson &
Germer

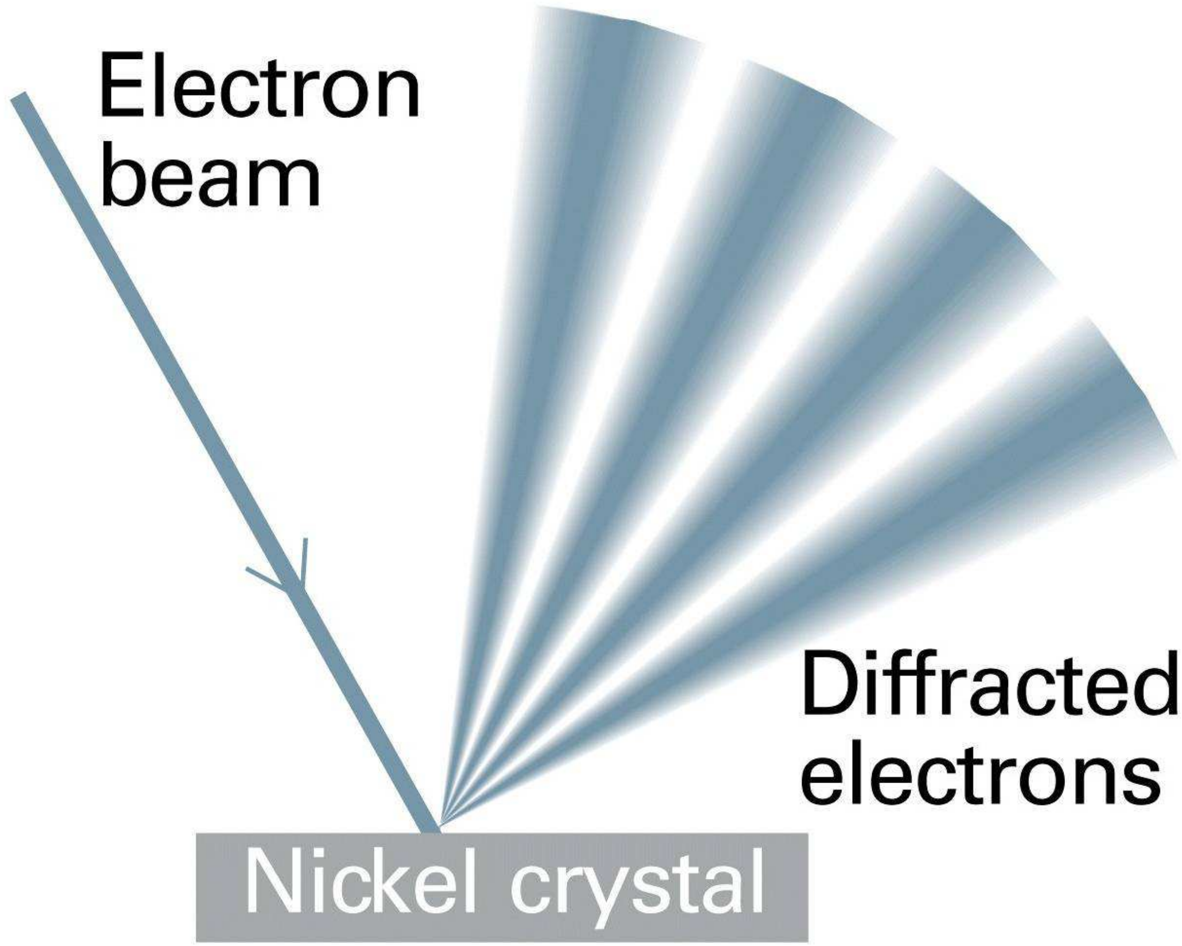
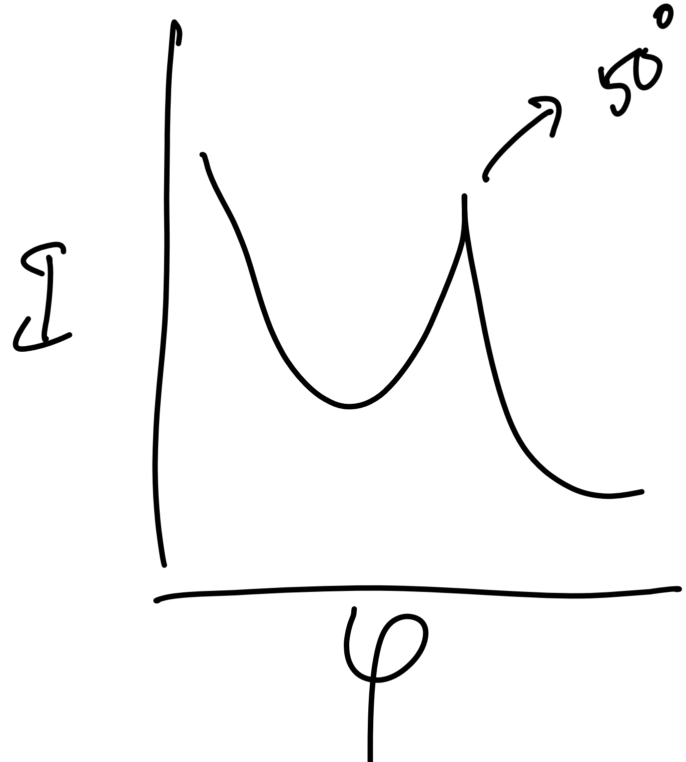
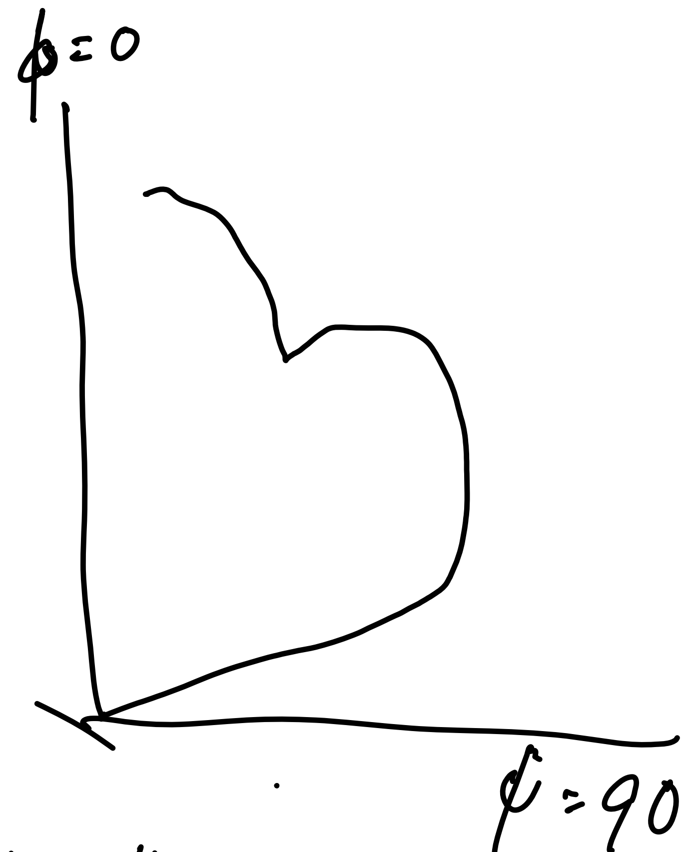


Figure 8-15
Atkins Physical Chemistry, Eighth Edition



1.65 Å



G.P. Thomson, "electrons"

$$\boxed{\lambda = \frac{h}{p}}$$

Group velocity & phase velocity
(PHL 110)

Schrödinger equation

$$y = A\sin(kx - \omega t) \rightarrow (1)$$

Classical wave equation $\leftarrow$

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$

$$\frac{\partial y}{\partial t} =$$

$$\frac{\partial y}{\partial x} =$$

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$f(x - \omega t)$

$$\frac{\partial y}{\partial x} = \,?\, \frac{\partial y}{\partial t} \quad \text{— (2)}$$

$$y = A \sin(kx + \omega t) \quad \text{— (3)}$$

Material particles in space ...

$$\psi = A \sin(kx - \omega t)$$

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

$$\psi = e^{i(kx - \omega t)}$$

1) 1st order derivative w.r.t 't'

2) 2nd order derivative w.r.t 'x'

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

Time dependent Schrödinger equation

$$E \Rightarrow i\hbar \frac{\partial \psi}{\partial t} = -\frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial x^2}$$

$$E = T + V$$

TDSE

kinetic energy — potential

$$\psi \qquad = \frac{\hbar^2 k^2}{2m} + V$$

$$i\hbar \frac{\partial \psi}{\partial t} = \left(-\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + V(x)\right)\psi(x,t)$$

Separation of variables

$$\Psi(x,t) = \psi(x)\, g(t)$$

Time Independent Schrödinger equation

$$-\frac{\hbar^2}{2m}\frac{d^2\psi(x)}{dx^2} + V(x)\,\psi(x) = E\,\psi(x)$$

$$H\psi = E\psi$$ — later

$$-\frac{\hbar^2}{2m}\nabla^2\psi + V(x,y,z)\,\psi = E\,\psi$$

$V(r,\theta,\varphi)$

$\psi(x,y,z)$

$V(x)\times\psi$

$kx\times\psi$

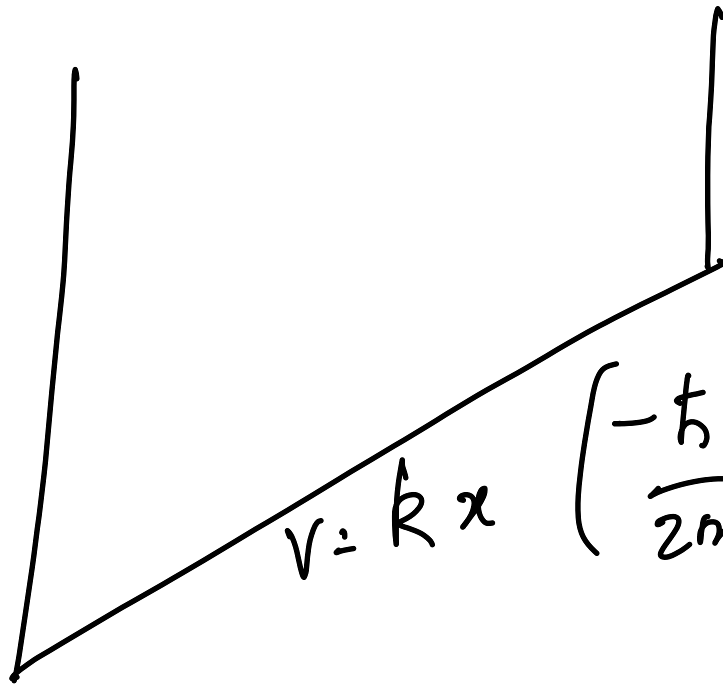
$$\hat{O}_p\,\psi = \text{constant} \times \psi$$ indep of x,y,z

$$\left(-\frac{\hbar^2}{2m}\nabla^2 + \hat{V}\right)\psi = \text{constant}\times\psi$$

$$\left(-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}+0\right)\times\psi$$

$$V = 0$$

L



$$\left(-\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + kx\right)\psi = E\psi$$

eigen value equation → $\hat{Op}\, f$ = constant f

$kx\, f$ = not a constant f

$kx\, x^2 = kx^3$

$x \times f' = \text{constant} \times f'$ → eigen value

↳ eigen function of x

$$\frac{d^2}{dx^2} \sin kx = -k^2 \sin kx$$

operator ↗ $\frac{d^2}{dx^2}$; $\sin kx$ ↑ eigen function; $-k^2$ ↑ eigen value.

$$\frac{d}{dx} \sin kx = k \cos kx$$

Op $\quad f(x) \quad\quad g(x)$