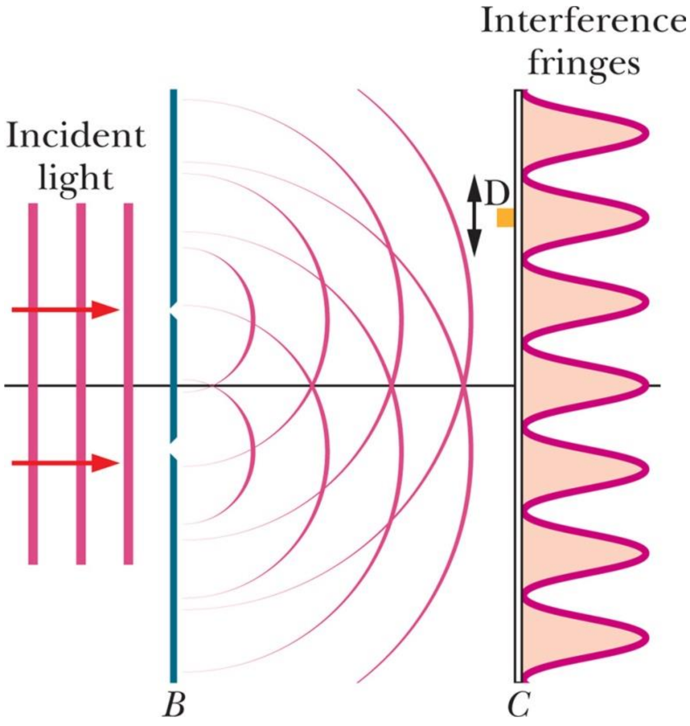
Copyright statement

- The images and the pictures in this lecture are provided by the CDs accompanied by the books
  1. University Physics, Bauer and Westfall, McGraw-Hill, 2011.
  2. Principles of Physics, Halliday, Resnick, and Walker, Wiley, 8^{th} and 9^{th} Ed.
- The rest is made by me.

빛의 파동적 성질

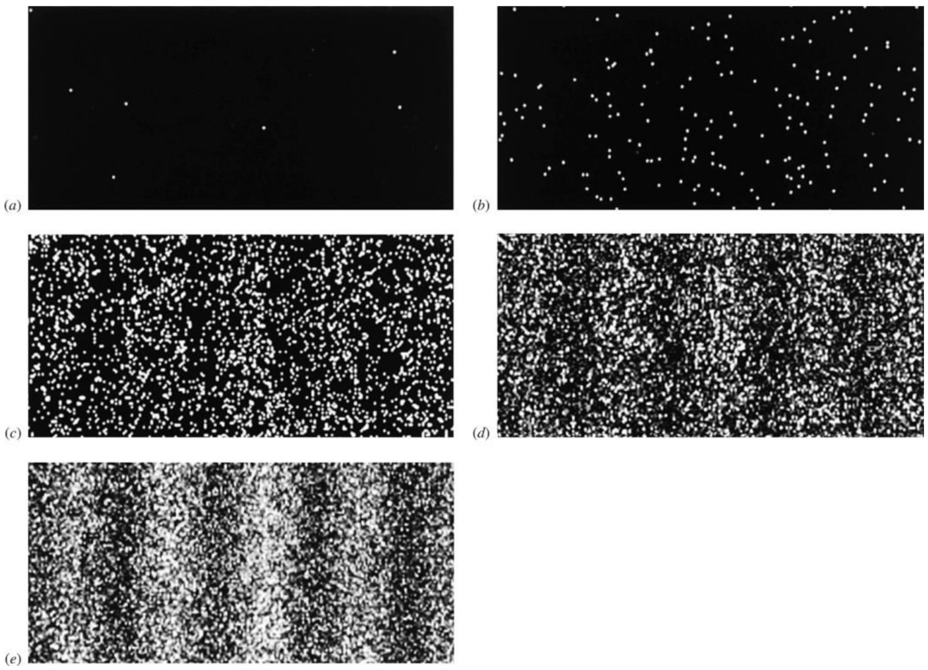
(1) 기본적 실험



광자를 발견할 확률

$$P \propto I \propto E^2$$

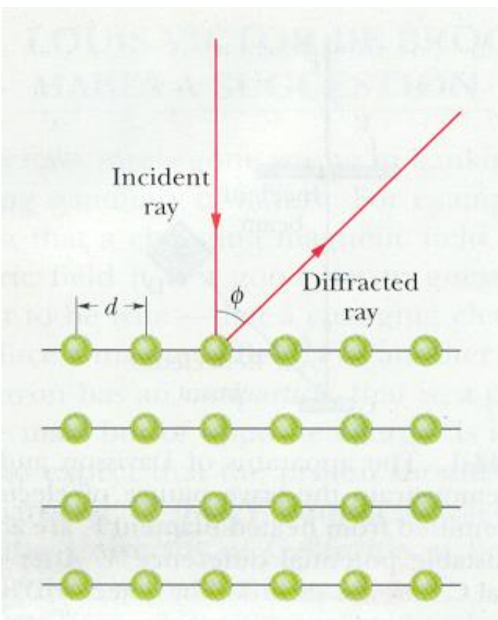
(2) 단일 광자 실험

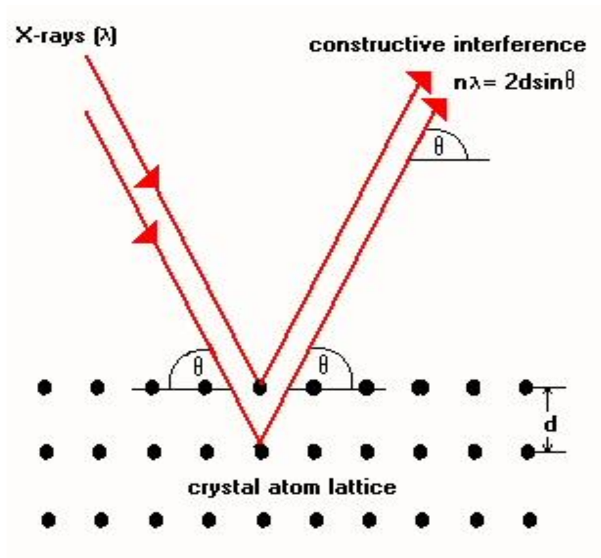


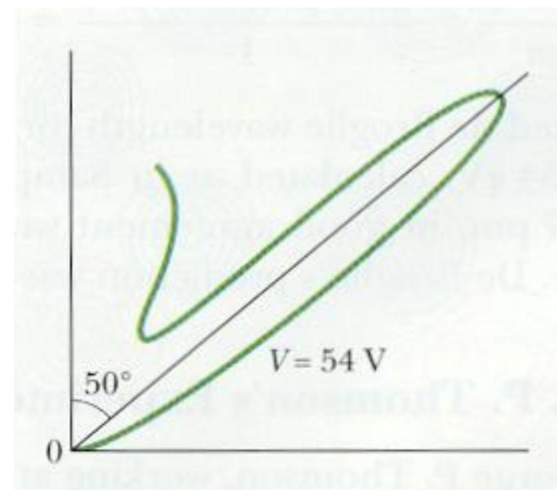
전자의 파동적 성질

Davisson과 Germer의 실험

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





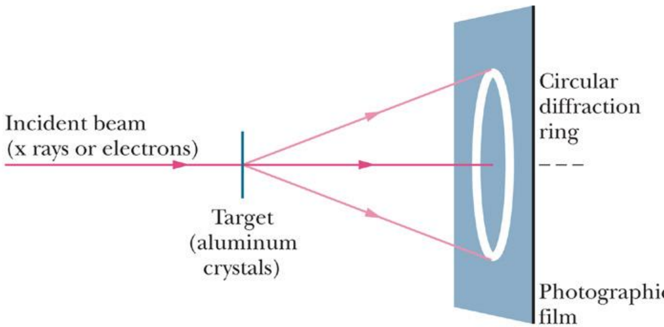


Baseball: $v = 35\text{m/s}, \quad m = 150\text{g}$

$$\lambda = \frac{h}{p} = \frac{h}{mv} = 1.26 \times 10^{-34}\,\text{m}$$

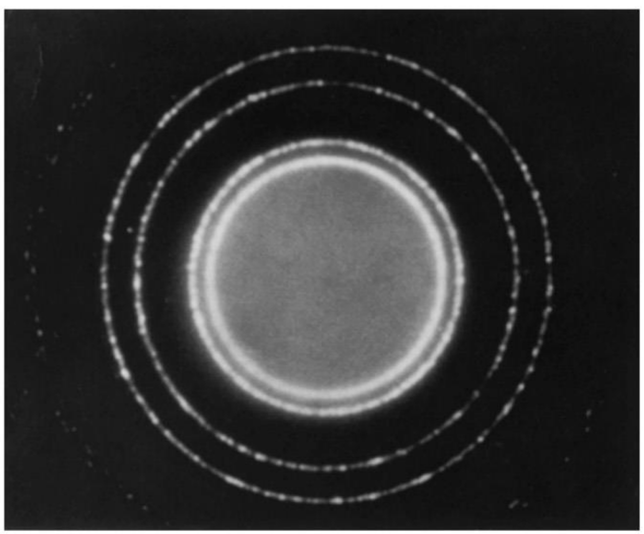
전자의 파동적 성질 2

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



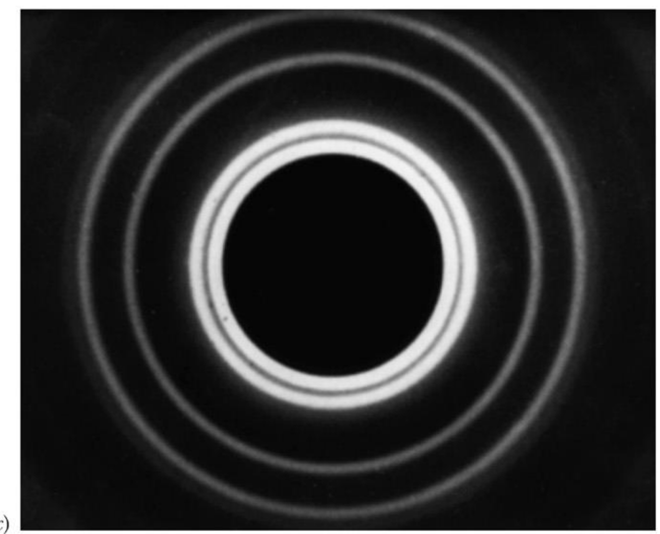
(a)

(b)



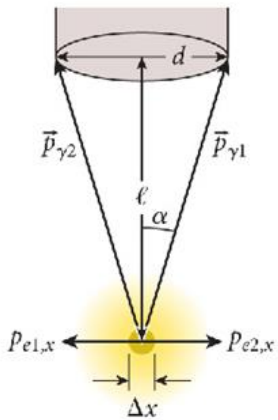
엑스선

(c)



전자

Uncertainty principle



$$\Delta x = \frac{\lambda}{2\sin\alpha} \approx \frac{\lambda l}{d}$$

$$\Delta p_x = 2|p_{\gamma 1,x}| = \frac{2h\sin\alpha}{\lambda} \approx \frac{h}{\Delta x}$$

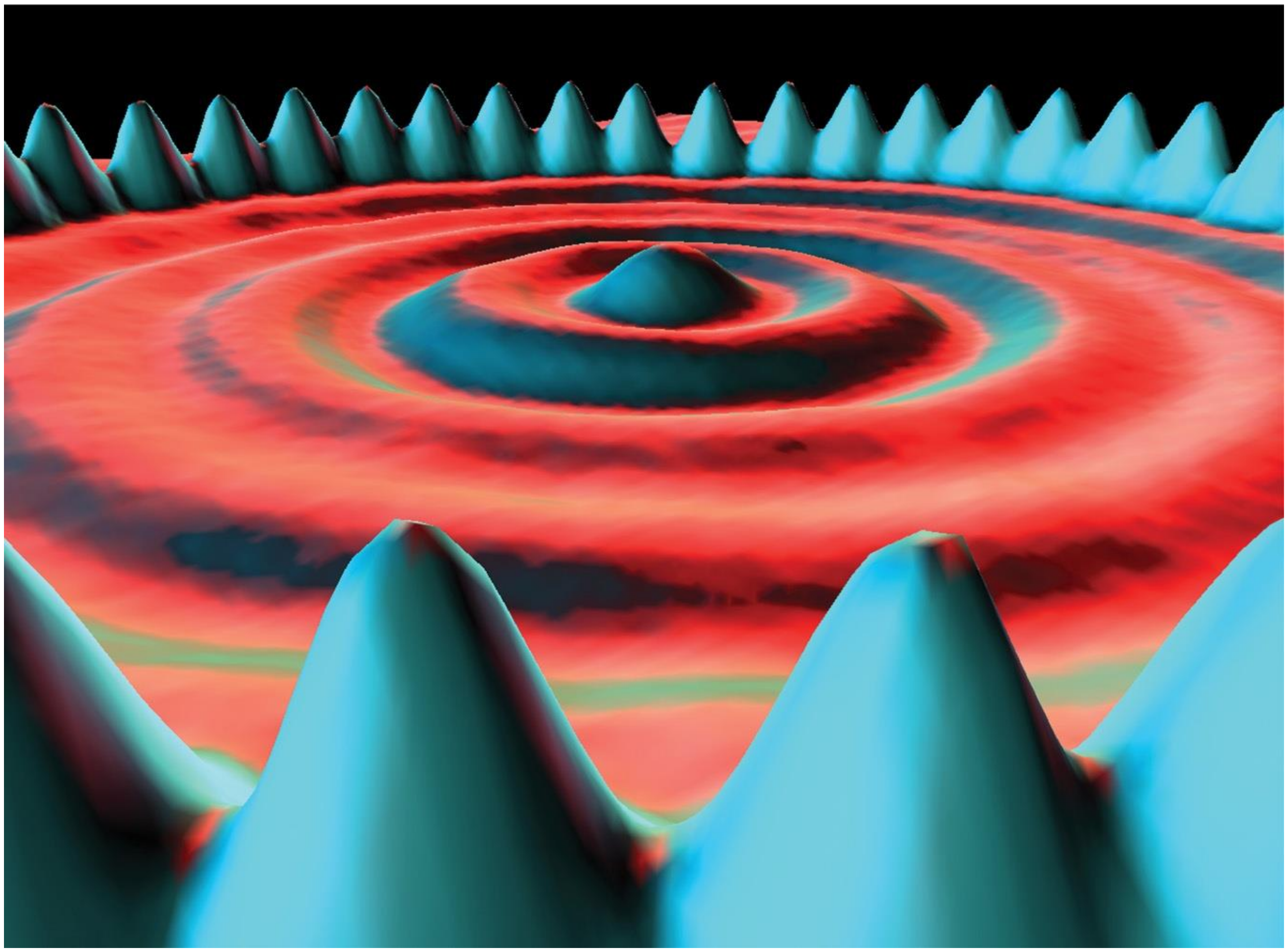
Energy-time uncertainty

$$\Delta E = \Delta \frac{p^2}{2m} = \frac{p \Delta p}{m} = v \Delta p$$

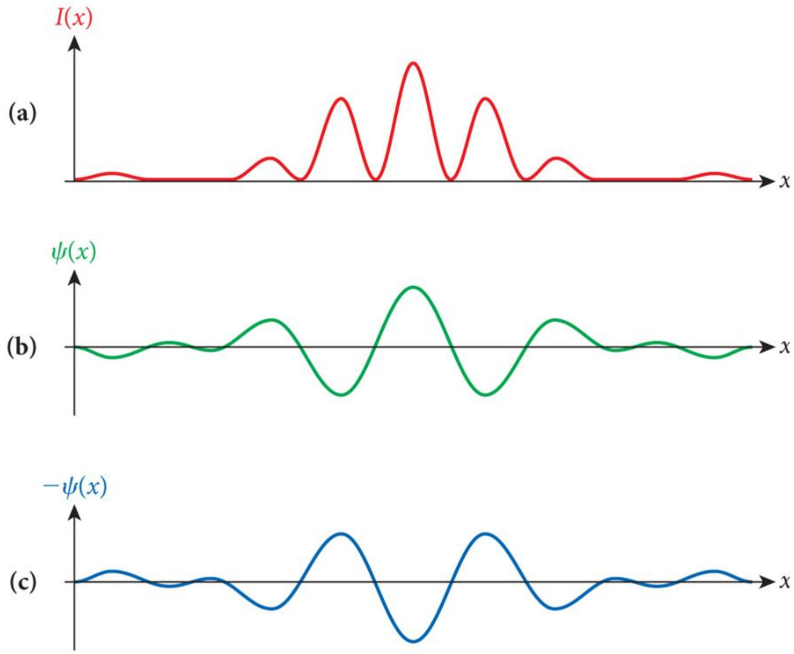
$$\Delta t = \frac{\Delta x}{v}$$

$$\Delta E \Delta t = \Delta p \Delta x \geq \frac{\hbar}{2}$$

Chapter 37 Quantum mechanics



Wave function



$$\rho(x)dx = |\psi(x)|^2 dx$$

Schrodinger equation

$$\Psi(x,y,z,t) = \psi(x,y,z)e^{-i\omega t}$$

$$\frac{d^2\psi}{dx^2} + \frac{8\pi^2 m}{h^2}\Big[E - U(x)\Big]\psi = 0$$

$$2\pi/\lambda = k$$

Free particle

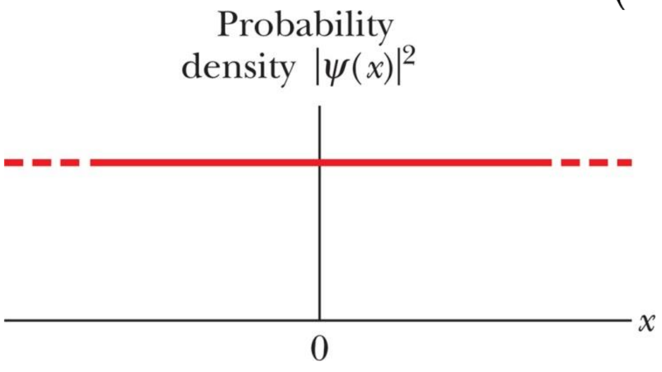
$$\frac{d^2\psi}{dx^2} + \frac{8\pi^2 m}{h^2}\frac{mv^2}{2}\psi = 0$$

$$\frac{d^2\psi}{dx^2} + \left(2\pi\frac{p}{h}\right)^2\psi = 0$$

$$\frac{d^2\psi}{dx^2} + k^2\psi = 0$$

$$\psi = Ae^{ikx} + Be^{-ikx}$$

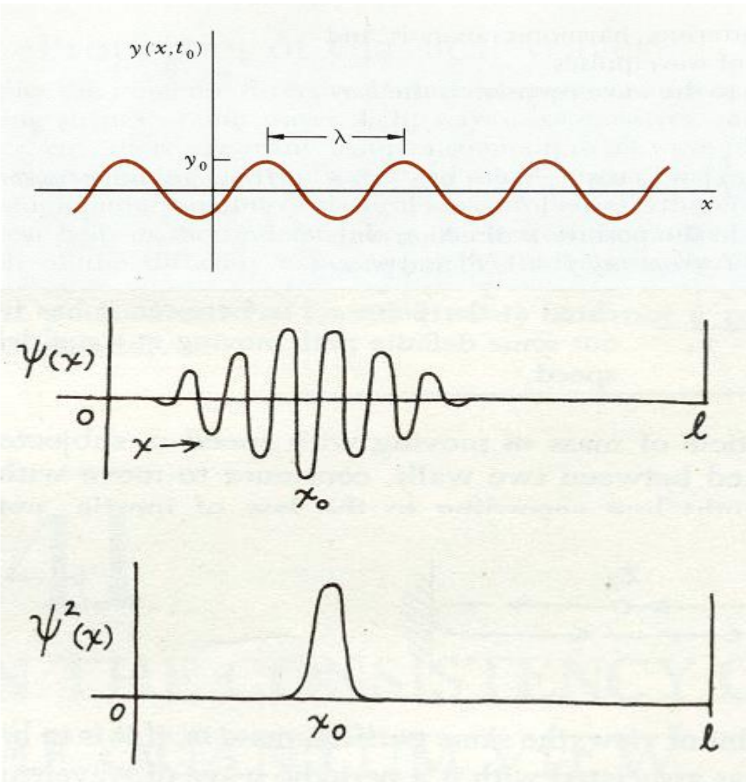
$$\Psi(x,t) = \psi(x)e^{-i\omega t} = Ae^{i(kx-\omega t)} + Be^{-i(kx+\omega t)}$$



Prob. density

$$|\psi|^2 = |\psi_0 e^{ikx}|^2 = |\psi_0|^2$$

Heisenberg's uncertainty principle



$$\Delta x \cdot \Delta p_x \geq \hbar$$

$$\Delta y \cdot \Delta p_y \geq \hbar$$

$$\Delta z \cdot \Delta p_z \geq \hbar$$

example

Electron: $m_e = 9.11\times10^{-31}\,\text{kg},\ v = 2.05\times10^{6}\,\text{m/s},\ \Delta v = 1.5\%$

$$p_e = m_e v = 1.87\times10^{-24}\,\text{kg}\cdot\text{m/s}$$

$$\Delta x = \frac{h}{\Delta p} = \frac{6.63\times10^{-34}\,\text{J}\cdot\text{s}}{(0.015)(1.87\times10^{-24}\,\text{kg}\cdot\text{m/s})}$$

$$= 2.37\times10^{-8}\,\text{m} \approx 24\text{nm} \Rightarrow 100\text{atomic diameter}$$

Golfball: $m = 45\text{g},\ v = 35\text{m/s},\ \Delta v = 1.5\%$

$$\Delta x = \frac{h}{\Delta p} = 3\times10^{-32}\,\text{m}$$

파동역학

파동 ⇔ 입자 => 물질파 => 파동역학

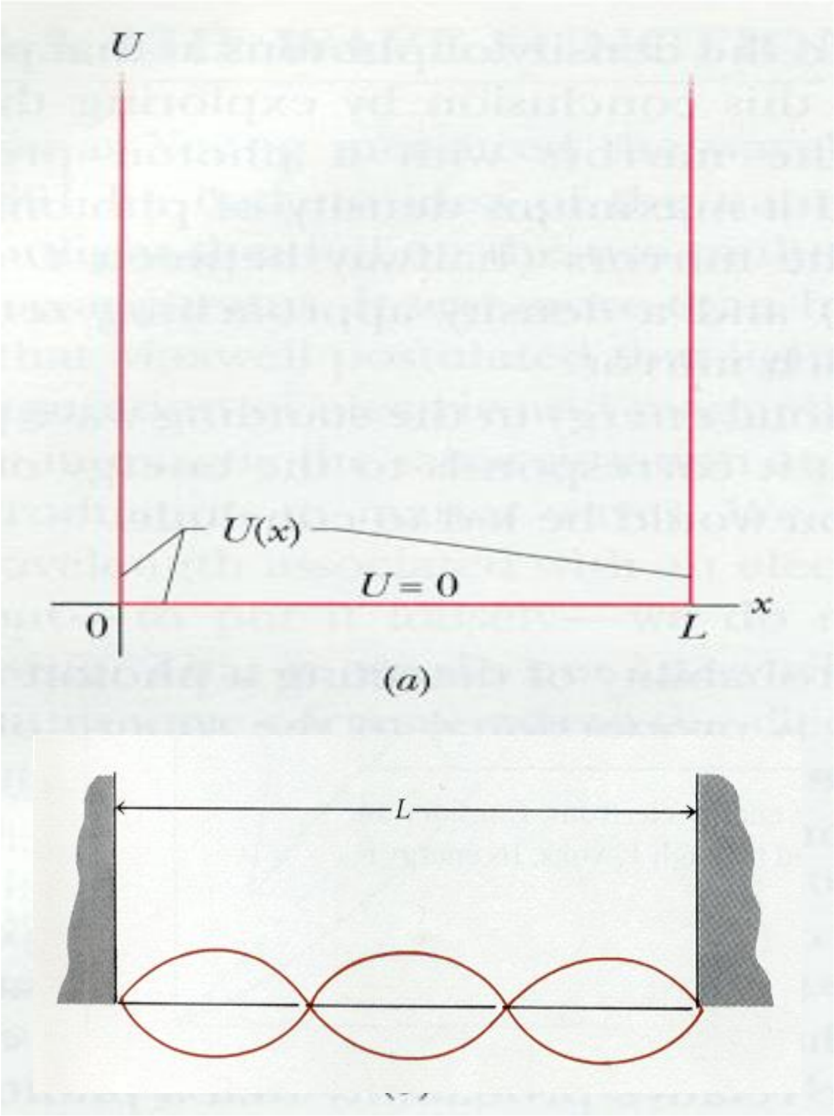
$$\psi(\vec{r}, t) = Ae^{i(\vec{k}\cdot\vec{r} - \omega t)}$$

$$E = hf = \frac{h}{2\pi}(2\pi f) = \hbar\omega$$

$$p = \frac{h}{\lambda} = \frac{h/2\pi}{\lambda/2\pi} = \hbar\left(\frac{2\pi}{\lambda}\right) = \hbar k$$

$$\int \psi^2(x,t)d\mathbf{x} = 1 \Rightarrow |\psi(x,t)|^2 : probability$$

1차원 상자

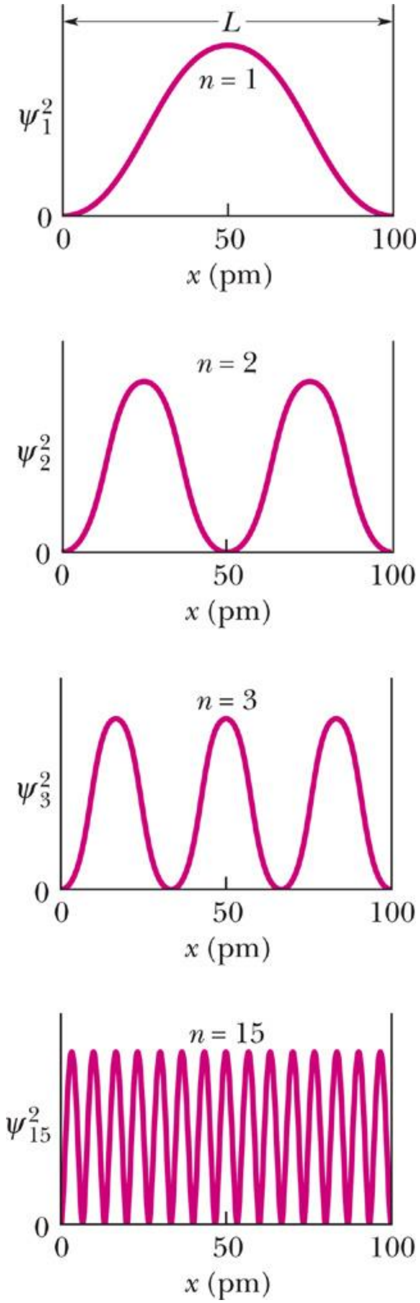


$$n\lambda = 2L$$

$$E = K + U = \frac{p^2}{2m}$$

$$p = \frac{h}{\lambda} = \frac{h}{2L/n}$$

$$\therefore E_n = \frac{h^2}{8mL^2} n^2$$



갇힌 전자의 파동함수

$$\psi_n(x) = A\sin\left(\frac{n\pi}{L}x\right), \ (n = 1, 2, 3, \cdots)$$

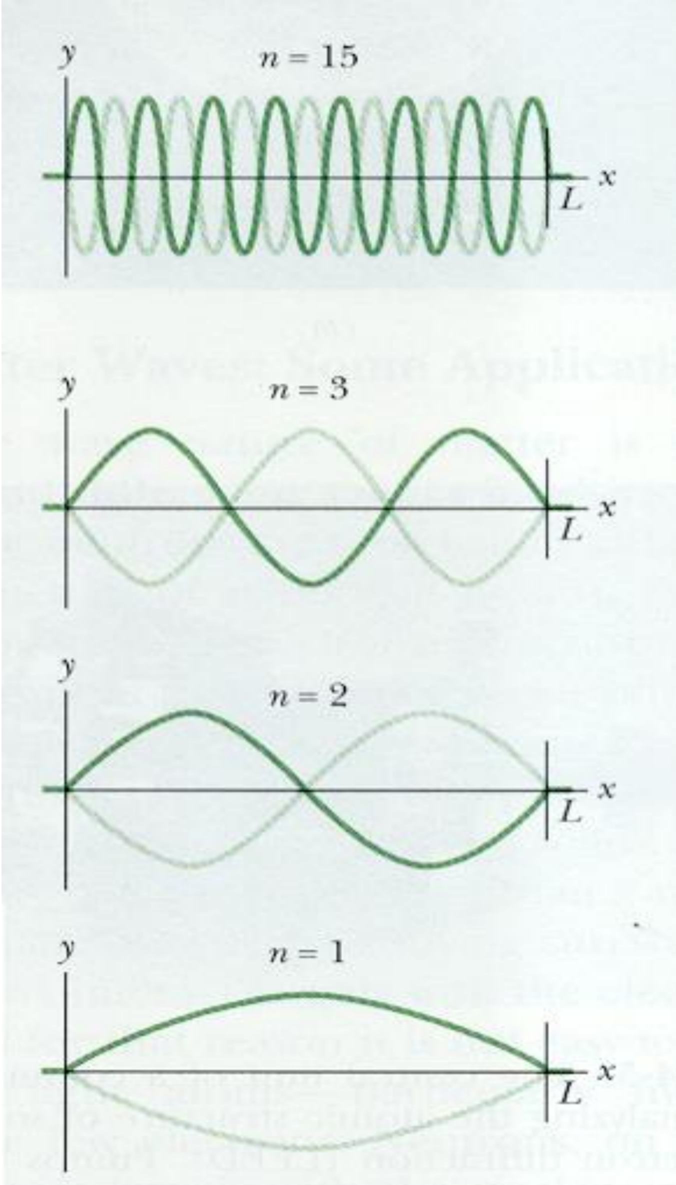
확률 $$p(x)dx = |\psi_n(x)|^2 dx$$

$$p(x) = A^2\sin^2\left(\frac{n\pi}{L}x\right), \ (n = 1, 2, 3, \cdots)$$

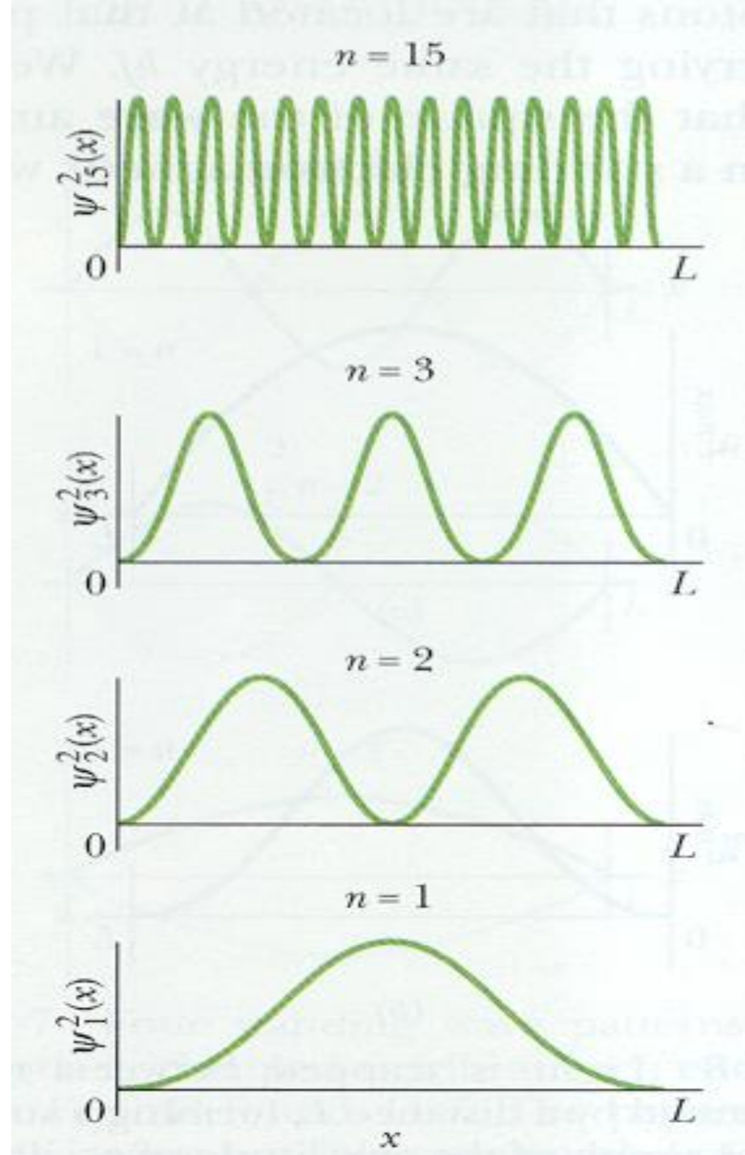
x_1과 x_2 사이에서 검출할 확률

$$\int_{x_1}^{x_2} p(x)dx = \int_{x_1}^{x_2} A^2\sin^2\frac{n\pi x}{L}dx$$

$$\int_{-\infty}^{\infty} p(x)dx = 1 \longrightarrow A = \sqrt{\frac{2}{L}}$$

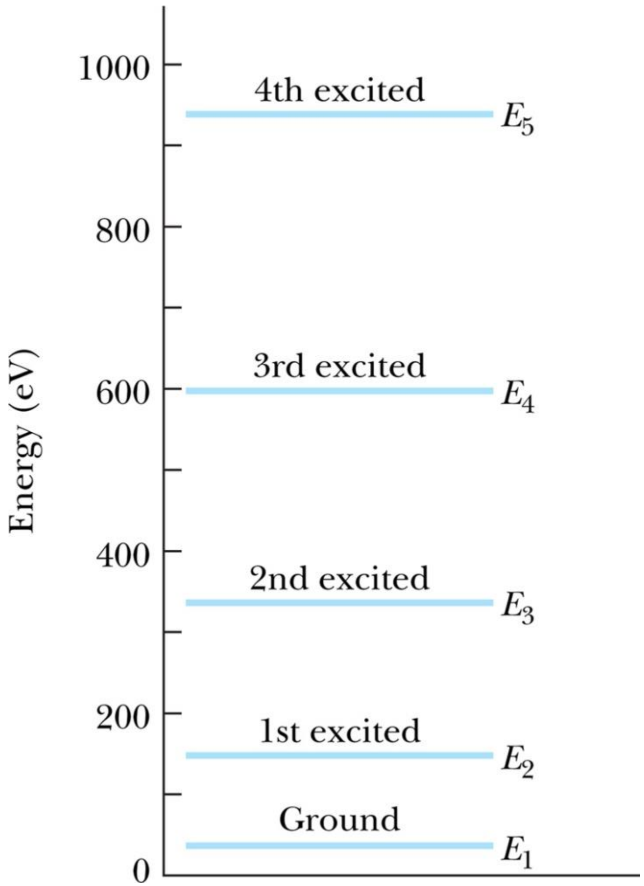


$$\psi(x,t)$$

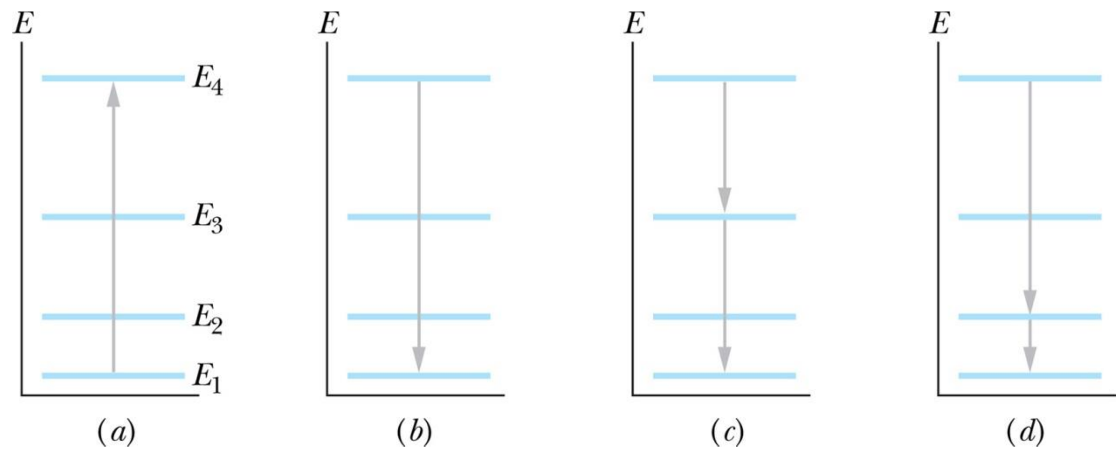


$$\left|\psi(x,t)\right|^2 : probability$$

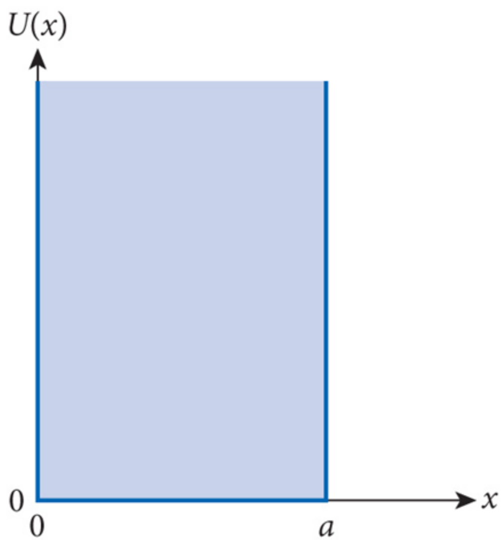
에너지의 변화



$$\Delta E = E_{\text{high}} - E_{\text{low}}$$



Infinite potential well



$$U(x) = \begin{cases} \infty & \text{for } x < 0 \\ 0 & \text{for } 0 \le x \le a \\ \infty & \text{for } x > a. \end{cases}$$

$$\psi(0) = \psi(a) = 0$$

$$k = \frac{n\pi}{a}, \;\; n = 1, 2, 3, \cdots$$

$$E = \frac{\hbar^2 k^2}{2m} = \frac{\hbar^2 n^2 \pi^2}{2ma^2}$$

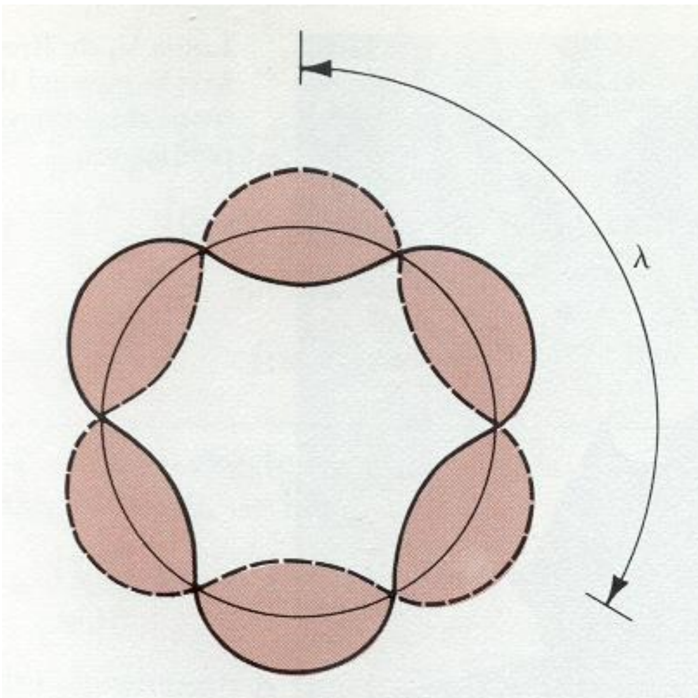
normalization

$$1 = \int_{-\infty}^{\infty} |\psi(x)|^2 dx = |D|^2 \int_0^a \sin^2 \frac{n\pi}{a} x = \frac{|D|^2}{2}$$

$$\therefore \; \psi(x) = \sqrt{\frac{2}{a}} \sin \frac{n\pi x}{a}$$

관계 ID가 rId8인 이미지 부분을 파일에서 찾을 수 없습니다.

Bohr의 수소원자 모형



(1) 수소원자는 원(타원)궤도를 돈다.
(2) 이 상태를 정상상태라고 하며 에너지를 잃지 않는다.
(3) 에너지를 방출하거나 흡수할 때는 한 정상상태에서 다른 정상상태로 갈 때 나타난다.
(4) 정상상태에서 각운동량은

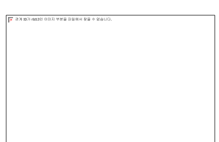
$$L = n\hbar, \ (n = 1, 2, 3, \cdots)$$

만을 갖는다.

$$\frac{1}{4\pi\epsilon_0}\frac{e^2}{r^2} = \frac{mv^2}{r}$$

$$r = \frac{h^2\epsilon_0}{\pi m e^2}n^2 = an^2, \ (n = 1, 2, 3, \cdots)$$

$$mvr = n\hbar$$



$$a = \frac{h^2\epsilon_0}{\pi m e^2} = 5.3 \times 10^{-11} \ \mathrm{m}$$

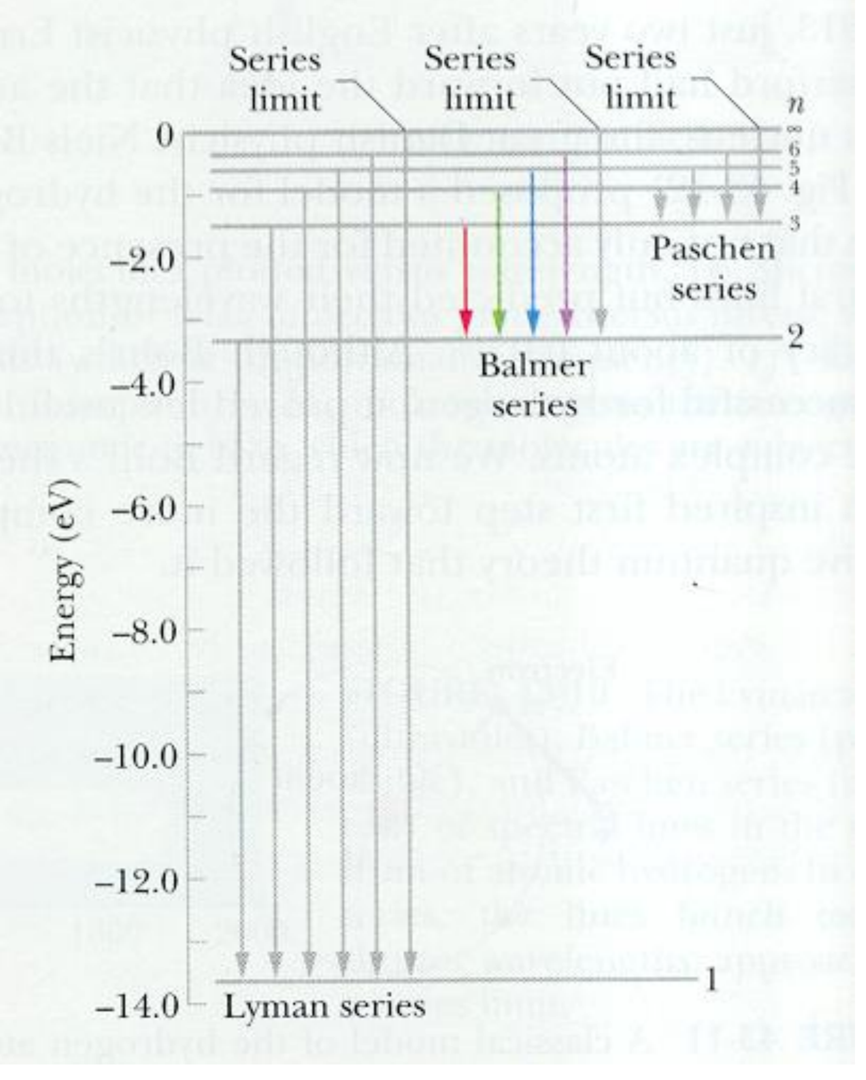
양자화된 에너지

에너지 변화 $hf = \Delta E = E_{\text{high}} - E_{\text{low}}$

$$\frac{1}{\lambda} = -\frac{me^4}{8\epsilon^2 h^3 c}\Big(\frac{1}{n_{\text{high}}^2} - \frac{1}{n_{\text{low}}^2}\Big) = R\Big(\frac{1}{n_{\text{low}}^2} - \frac{1}{n_{\text{high}}^2}\Big)$$

Rydberg 상수

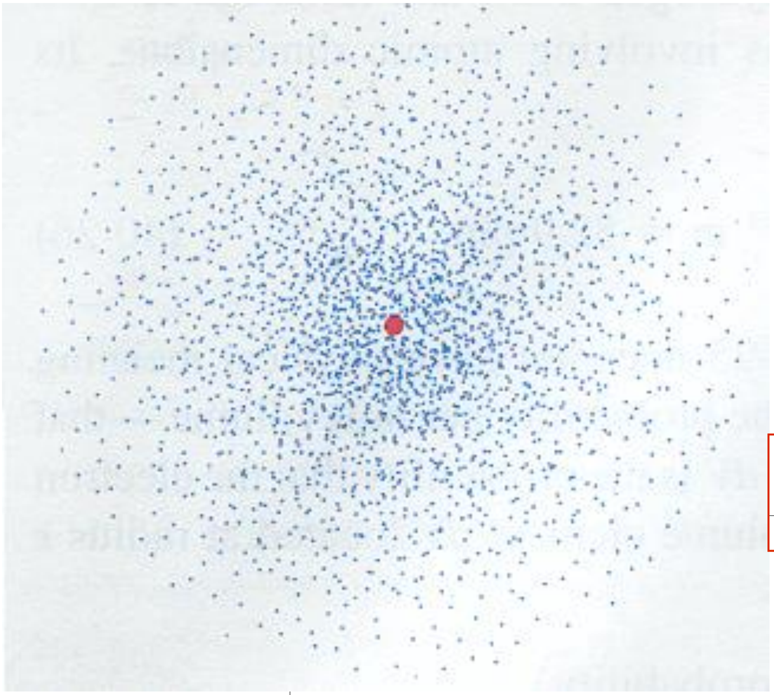
수소원자에 대한 양자역학적 이해



$$E_n = -\frac{13.6}{n^2}\,\text{eV}$$

$$hf = E_m - E_n$$

전자분포



$n=1$