CLICKER

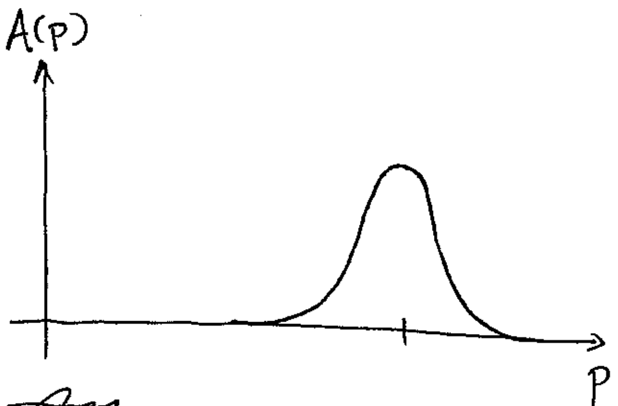
# LAST TIME:

general electron state → quantum superposition of position eigenstates described by wavefunction $\psi(x)$

traveling electrons
→ exhibit wavelength $\lambda = \frac{h}{p}$ in diffraction experiments
BUT
→ not infinitely spread out

∴ WAVEPACKET


superposition of pure waves with different wavelengths [Sim]
= MOMENTUM EIGENSTATES




define $A(p)$: amount of wave with wavelength $\frac{h}{p}$

→ like wavefunction for momentum.

~~CLICKER~~

measure momentum → $|A(p)|^2$ gives prob. density for finding $p$ → state becomes (approximate) momentum eigenstate.

CLICKER

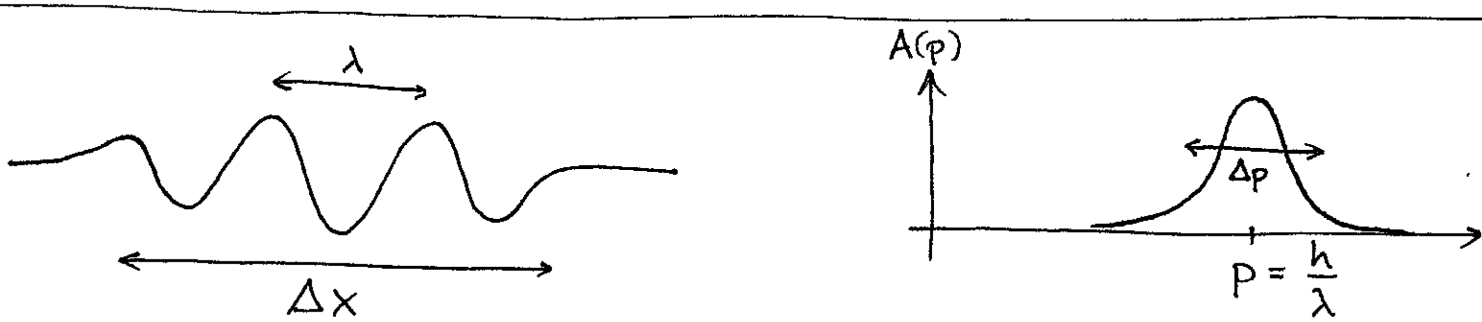
$\psi(x)$, $A(p)$: 2 descriptions of same state: (diagram)

$$A(p) = \frac{1}{\sqrt{h}} \int_{-\infty}^{\infty} dx\, \psi(x)\, e^{-i\frac{2\pi p}{h}x}$$

$\psi(x)$ → FOURIER TRANSFORM. → $A(p)$

$$\psi(x) = \frac{1}{\sqrt{h}} \int_{-\infty}^{\infty} dp\, A(p)\, e^{i\frac{2\pi p}{h}x}$$

---




CLICKER

$\psi(x)$ more ~~spread out~~ localized ⟺ $A(p)$ more ~~localized~~ spread out

= ~~more~~ less uncertainty in position

= ~~less~~ more uncertainty in wavelength/momentum

Precise relation: (true for any wavefn)

$$(\Delta x)(\Delta p_x) \geq \frac{h}{4\pi}$$

HEISENBERG UNCERTAINTY PRINCIPLE

3D: also have

$$(\Delta y)(\Delta p_y) \geq \frac{h}{4\pi}$$

$$(\Delta z)(\Delta p_z) \geq \frac{h}{4\pi}$$

CLICKER

No states have definite position & momentum.