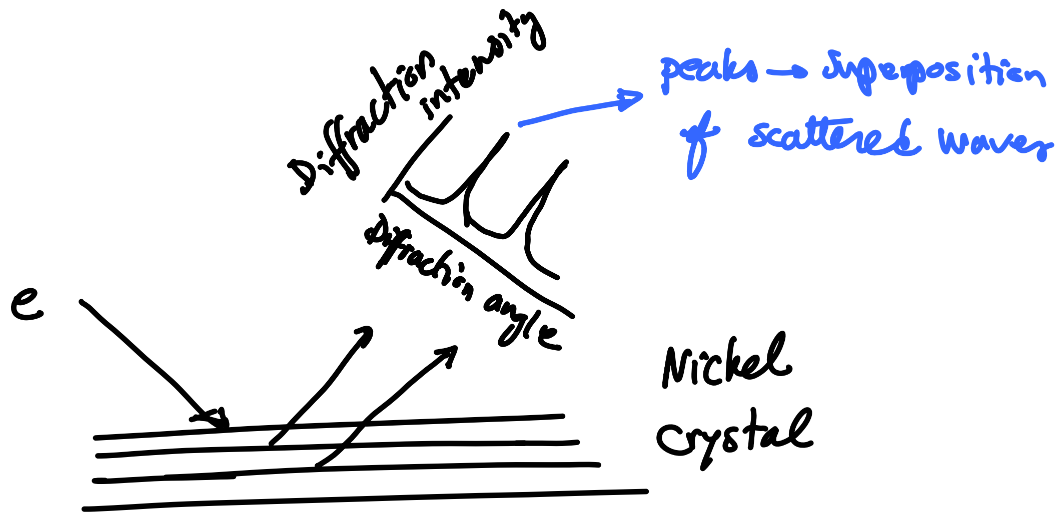
Note Title 1/8/2008

electron → particle

wave behavior

Davisson & Germer Experiment: (1927)



de Broglie 1924:

An electron momentum p has wavelength:

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

or: $p = \frac{h}{\lambda} = \frac{2\pi\hbar}{\lambda} = \hbar k$ $\qquad \lambda = \frac{2\pi}{k}$

$$\psi(r,t) \sim e^{-i\left(\frac{E}{\hbar}t - k\cdot r\right)}$$

When is a particle a wave?

Photon
electron — particle ?
neutron — wave ?
proton
⋮

$$\lambda = \frac{2\pi}{k}$$

photon $m=0$:

$$\lambda = \frac{2\pi c\hbar}{\underbrace{\underbrace{kc}_{\omega}\hbar}_{E}} = \frac{2\pi\hbar c}{E}$$

6.6×10^{-34} J·s

electron $m\neq 0$:

$$\lambda = \frac{2\pi\hbar}{\underbrace{k\hbar}_{p=\sqrt{2mE}}} = \frac{2\pi\hbar}{\sqrt{2mE}}$$

9.1×10^{-31} kg

	E	λ	$d = 10$ nm
Photon	2.6 ev (blue)	475 nm	$\lambda > d \Rightarrow$ wave
	1 Mev	1.2×10^{-3} nm	$\lambda \ll d \Rightarrow$ particle
Electron	2.6 ev	0.8 nm	$\lambda \ll d \Rightarrow$ particle
	1 mev	39 nm	$\lambda > d \Rightarrow$ wave

particle : $F = ma$

wave ?