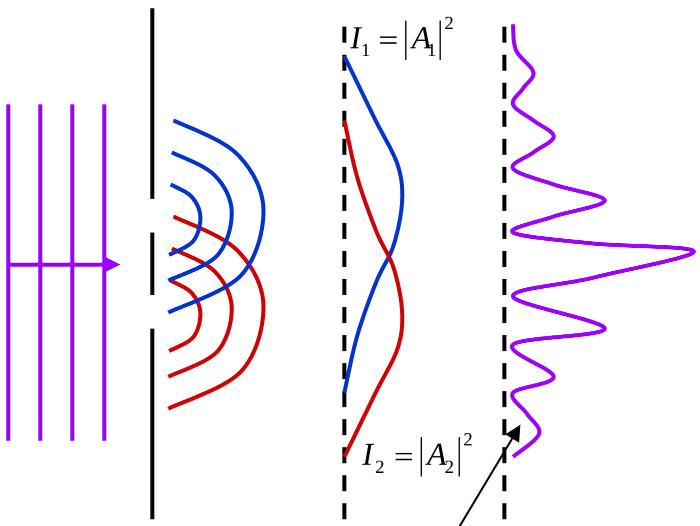
# Particles and Waves

Now we consider the classical separation of particles and waves.

The 2-slit experiment:

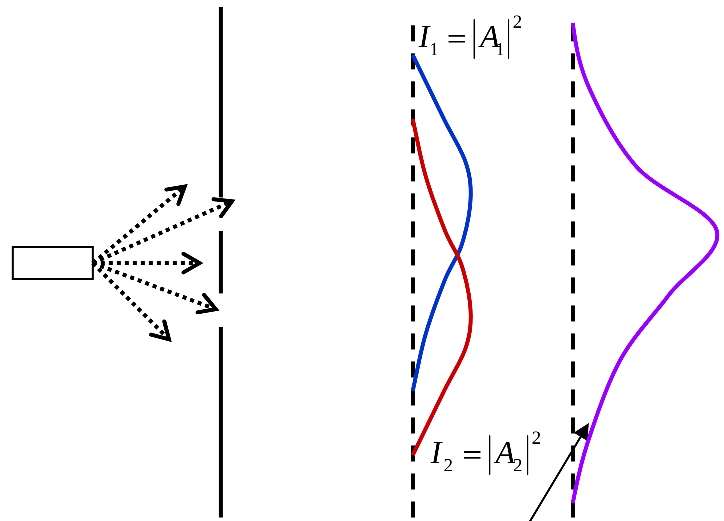
**Waves**: add at the amplitude level so there is interference.




$$I_{total} = |A_1 + A_2|^2$$
$$= A_1^2 + 2A_1A_2 + A_2^2$$

interference

**Particles**: add at the intensity level so there is no interference.




$$I_{total} = I_1 + I_2$$

# de Broglie

- So, Maxwell and the 2-slit experiment say light is a wave, but the photoelectric effect and Compton say light is a stream of particles with momentum $p=h/\lambda$.

In 1924 de Broglie suggest that our classical separation of waves an particles is only an <u>estimate</u>.

Using the results of Einstein and Planck:

$$E = mc^2 \quad E = h\nu \qquad \left( E = h\nu = h\frac{c}{\lambda} = mc^2 \rightarrow h\frac{1}{\lambda} = mc = p \right)$$

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

Everything with momentum has a wavelength.

Why don't we see things acting like waves?

# Davisson-Germer

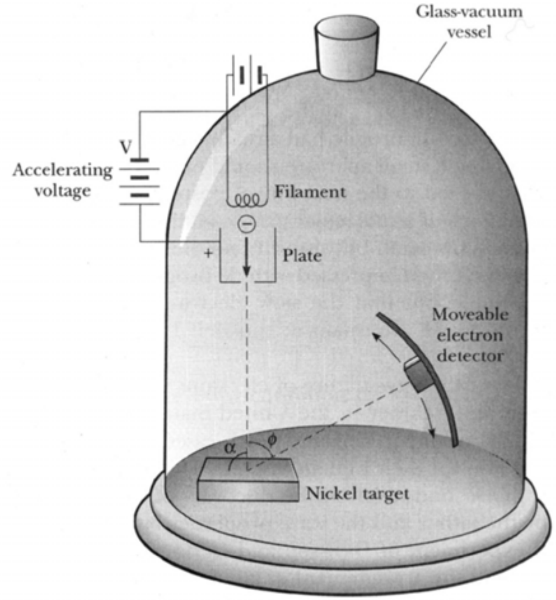
If de Broglie is correct, then we should see electrons interfering like waves...

Electron diffraction from Ni, the equivalent of the 2-slit exp for 54 eV electrons:

$$m\lambda = D\sin\theta$$

order=1

spacing, for Ni D=215 pm

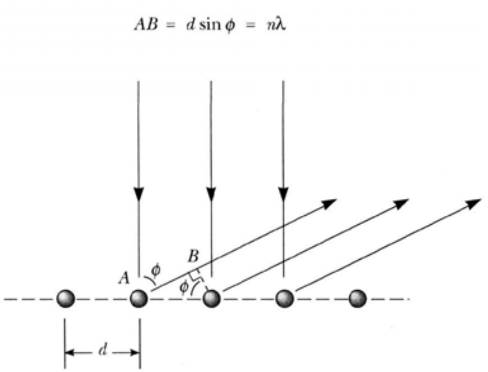


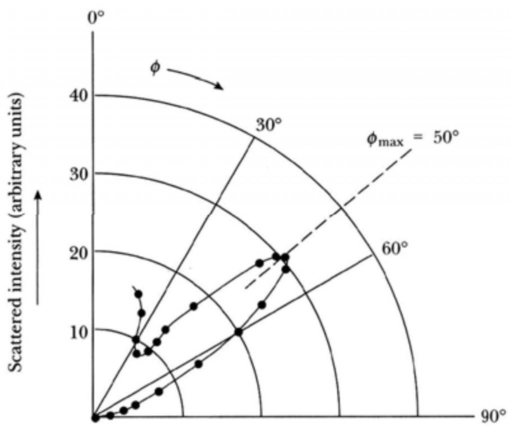

Diffraction:

$$\lambda = (215\text{ pm})\sin\left(50^\circ\right) = 165\text{ pm}$$

de Broglie (for 54 eV electrons):

$$\lambda = \frac{h}{p} = 165\text{ pm}$$




**<u>de Broglie is correct</u>**