Wave-Particle Duality of Matter
Louis de Broglie - 1923

For Light:

From Planck $E = h\nu = hc/\lambda$

From Einstein $E = pc = (mc)c = mc^2$

Y $hc/\lambda = mc^2$

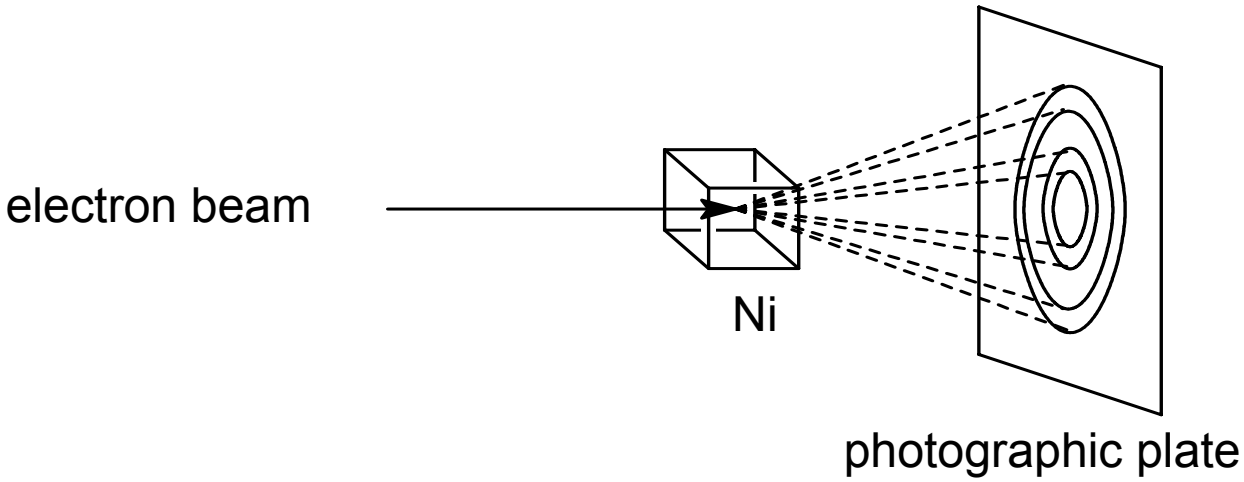
^ $\lambda = h/mc = h/p$

For Matter (by analogy):

$$\lambda = h/p = h/mv$$

Electron Diffraction

Davisson & Germer (Bell Labs.) - 1927

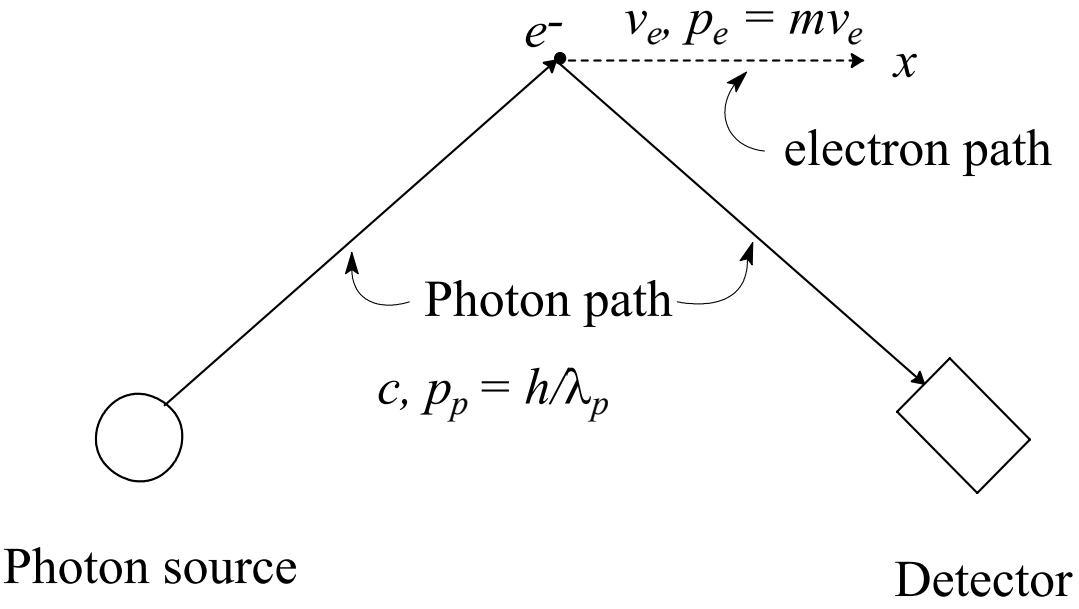


G. P. Thomson (son of J. J. Thomson) showed a similar pattern with very thin gold foil.

(J.J. Thomson won a Nobel prize for showing that the electron is a particle; G. P. Thomson won a Nobel Prize for showing that the electron is a wave.)

Heisenberg's Uncertainty Principle

A "Thought Experiment": How can we simultaneously measure the position and momentum of a moving electron?



Uncertainty in position (from optics):

$$\Delta x_e \ . \ \lambda_p$$

Uncertainty in momentum (if all photon momentum transferred to electron):

$$\Delta p_e = m\Delta v_e \ . \ p_p = h/\lambda_p$$

Combined, $\Delta x_e \Delta p_e \ . \ h$, or more rigorously

$$\Delta x \Delta p = h/4\pi$$