WAVE PROPERTIES OF PARTICLES

1. De Broglie waves.
2. Waves of what?
3. Describing a wave.
4. Phase and group velocities.
5. Particle diffraction.
6. Particle in a box.
7. Uncertainty principle I.
8. Uncertainty principle II.
9. Applying the uncertainty principle.

PARTICLE DIFFRACTION

Is there any experiment that confirms the existence of de Broglie waves?

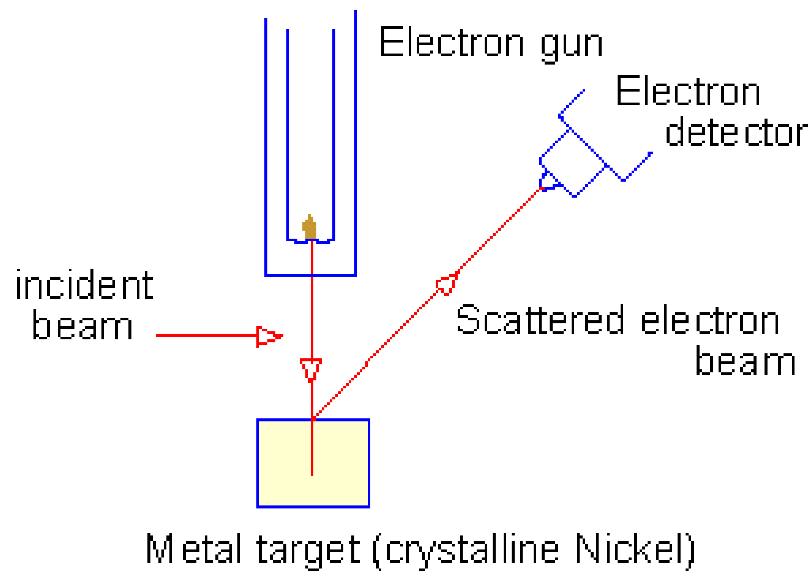
Let us watch this clip…

PARTICLE DIFFRACTION

In 1927, Davisson, Germer and Thomson demonstrated that electron beams are diffracted when they are scattered by the regular atomic arrays of crystals.

Davisson, Germer experiment used a block of nickel and they varied…

- The energy of the electrons in the primary beam
- The angle the electrons reach the target
- Position of the detector



PARTICLE DIFFRACTION

Classically:

• Scattered electrons will emerge in all directions.

• moderate dependence of electron's intensity on scattering angle

• Less dependence of electron's intensity on energy of the primary electrons.

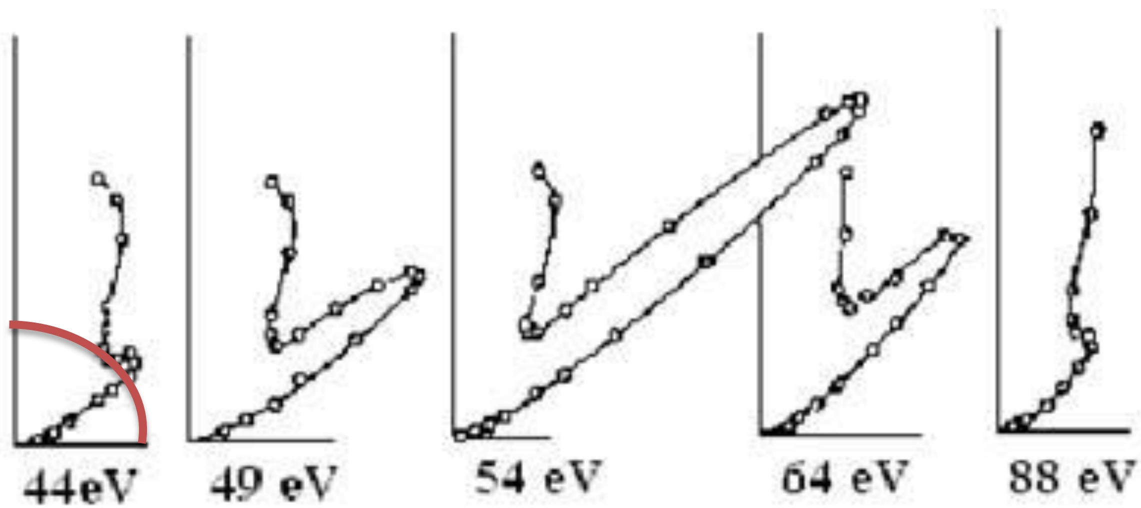
Then an accident happened!!

PARTICLE DIFFRACTION

After the accident the results were different!

Continuous variation of scattered electron intensity with angle…

Distinct maxima and minima were observed whose position depended upon the electron energy!!



PARTICLE DIFFRACTION

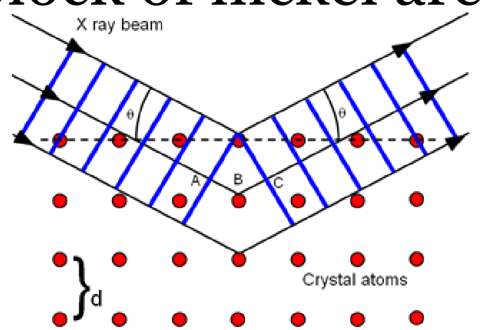
Two questions raised:

1. **What is the reason for this new effect?**
2. **Why did it not appear until the nickel target was baked?**

De Broglie's hypothesis suggested that electron waves are diffracted by the target like X-rays are diffracted by planes of atoms in a crystal.

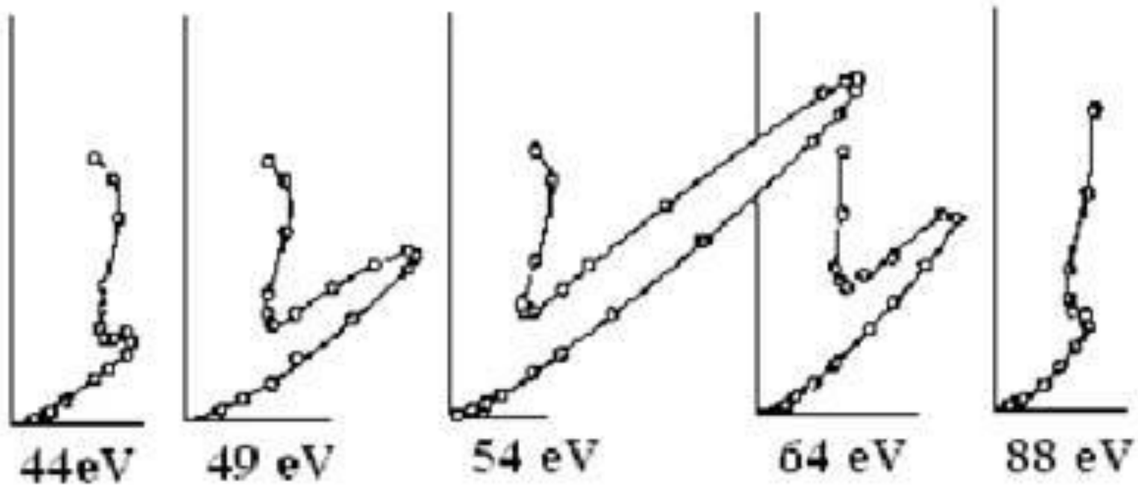
At high temperature the atoms of a block of nickel are arranged in a regular lattice.

$$2d\sin\theta = n\lambda$$

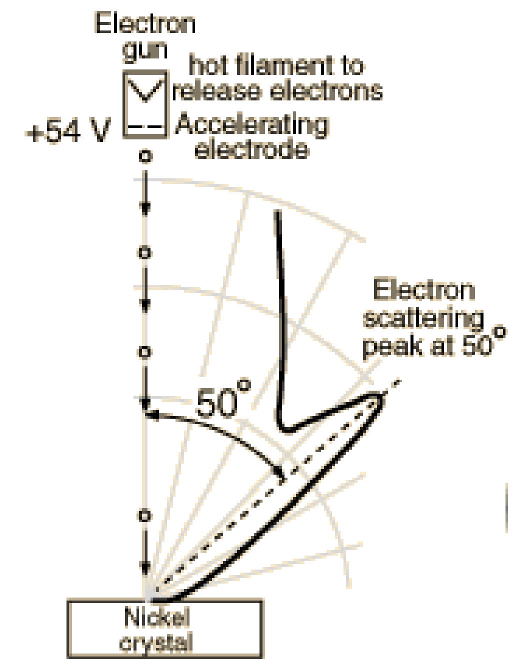


Is the electron diffraction consistent with this law?

PARTICLE DIFFRACTION



$$2d\sin\theta = n\lambda$$



At electron energy of 54 eV, a sharp maximum in the electron distribution occurred at 50° with original beam.

The angle of incidence relative to the Bragg planes is 65°.

The spacing between the planes 0.091 nm

1924 de Broglie's hypothesis

1927 Davisson-Germer experiment

1929 Nobel Prize for de Broglie

PARTICLE DIFFRACTION

Using diffraction law:

d = 0.091 nm

θ = 65°

n = 1

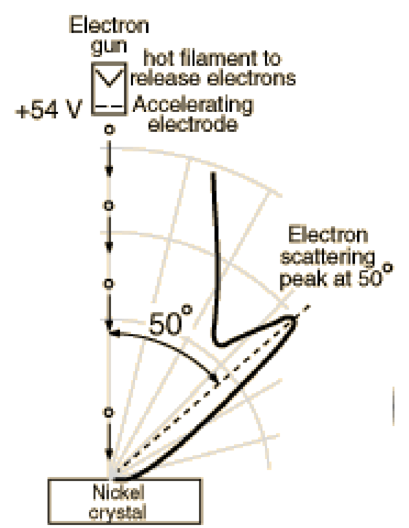
$$\lambda = 2d\sin\theta = (2)(0.091\,nm)(\sin 65) = 0.165\,nm$$

Using de Broglie's formula:

KE =54 eV = ½ mυ²

m = 9.1 × 10⁻³¹ kg

$$\lambda = \frac{h}{\gamma m\upsilon} = \frac{6.6\times10^{-34}\,J.s}{(1)(4\times10^{-24}\,m/s)} = 0.166\,nm$$



PARTICLE DIFFRACTION

Remember…

Particle diffraction is an experiment that confirms the existence of de Broglie waves.