ELECTRON DIFFRACTION EXPERIMENT

Aim: To measure the de Broglie wavelength of electron beam and to compare it's value with the theoretical value obtained from the accelerating potential.

Apparatus: Electron diffraction setup

Theory:

In 1924 deBroglie theorized that not only light posesses both wave and particle properties, but rather particles with mass - such as electrons - do as well. The wavelength of these 'matter waves' - also known as the de Broglie wavelength - can be calculated from Planks constant h divided by the momentum p of the particle.

In the case of electrons it is $\lambda = h/p = h/mv$. The acceleration of electrons in an electron beam gun with the acceleration voltage V_a results in the corresponding de Broglie wavelength.

We have $KE = mv^2/2 = eV_a$, which results to the velocity $v = (2.e.V_a/m)^{1/2}$. Substituting this we get

$\lambda = h/p = h/mv = h/[m.(2.e.V_a/m)^{1/2}] = h/(2meV_a)^{1/2}$

$\lambda = h/(2meV_a)^{1/2}$ ....(1)

Tube geometry

This de Broglie hypothesis can be verified experimentally by electron diffraction experiment. This wavelength can be obtained from the tube geometry as follows;

From figure we get,

$\tan(2\theta) = r/(l1 + l2)$

where $l_1 = L-R$ and $l_2 = (R^2-r^2)^{1/2}$

So $\tan(2\theta) = r/(L-R+(R^2-r^2)^{1/2})$

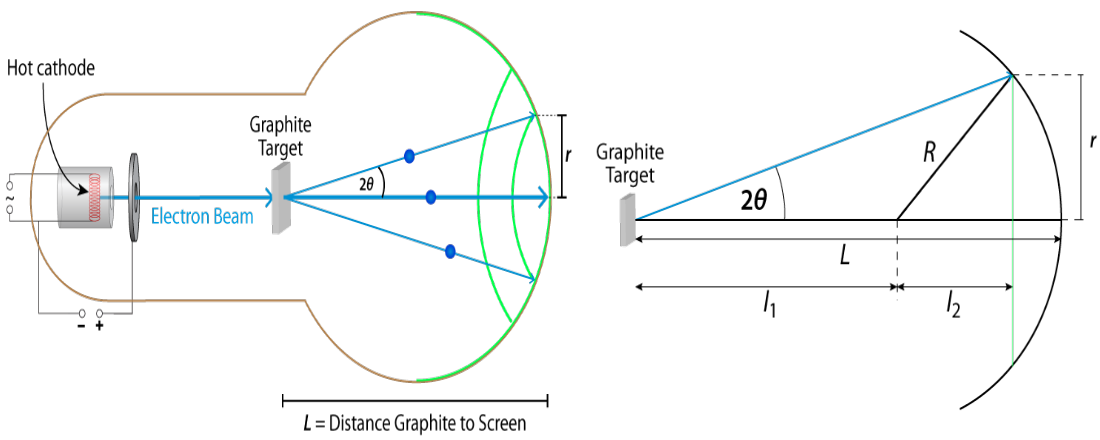
So, $\theta = (½).\tan^{(-1)}[r/(L-R+(R^2-r^2)^{1/2})]$.................(2)

From diffraction condition,

We have for the first diffraction ring,

$\lambda = d.\sin(\theta)$.........................(3)

where d is lattice spacing of graphite and θ is angle of diffraction which is given by equation(2) above. This angle can be measured experimentally.



Procedure for virtual experiment :

1) Go to the website https://virtuelle-experimente.de/en/elektronenbeugung/wellenlaenge/quantitativ.php
2) Change the slider of the potential and set the required potential.
3) Change the slider of the radius and measure the radius of first order ring.
4) For calculations use the standard values of Planck's constant, mass of electron and charge of electron, use the value of lattice constant $d = 2.13 \times 10^{-10}$m and the respective tube constants as Radius R = 6.35cm, Length L = 12.7cm.
5) Using the radius of the ring r, calculate the experimental wavelength using eqn(2) and eqn(3).
6) For the given potential, calculate the theoretical wavelength from eqn(1).

Observation table:

Sr	Accelerating potential V_a	λ (theoretical) using eqn(1)	Radius of the first order ring r	λ (experimental) using eqn(2&3)
1	4.5kV			
2	6kV			
3	8kV			
4	10kV			
5	12kV			

Conclusion :

The theoretical and experimental values of de Broglie wavelength are in good agreement. With increase in the accelerating potential, the de Broglie wavelength decreases as seen from the observation table.