Electron Diffraction

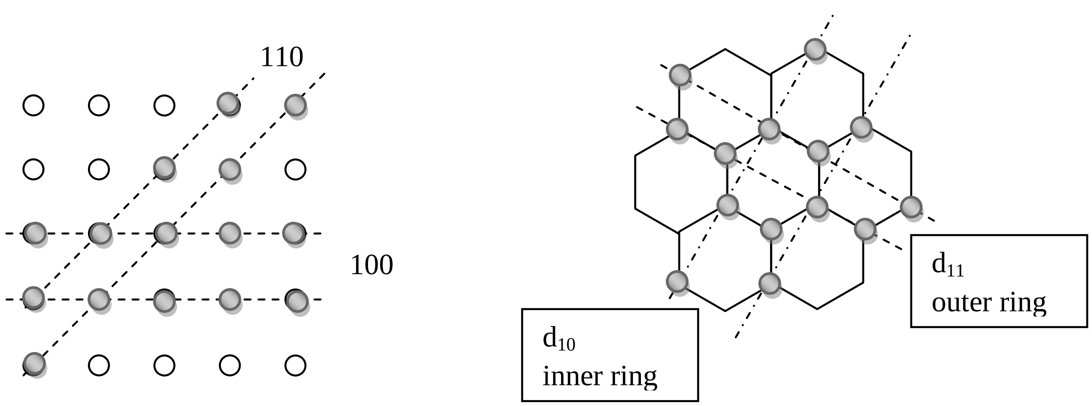
Objective:

The purpose of this experiment is to observe electron diffraction and to test the de Broglie hypothesis, which associates a wavelength with the momentum of a particle also that electrons can produce diffraction effects when scattered from a carbon target and lastly to measure the inter atomic spacing d_{10} and d_{11} of a carbon lattice. This will be accomplished by passing an electron beam through a graphite target and observing and measuring the diffraction rings.

Introduction:

If the graphite we are using were a single “one dimensional” crystal, we would see an electron diffraction pattern consisting of vertical lines on a screen. If it were a perfect two- or three-dimensional structure we would see a two dimensional dot pattern on the screen. Instead, it is not a single crystal and we will see a diffraction pattern of two rings, other rings are present however they are too dim and at too large of an angle to be observed with the current equipment.

Graphite consists of two-dimensional sheets loosely bond to other parallel two-dimensional sheet. Within each sheet the atoms are arranged in a hexagonal lattice. Shown below are pictorial views of a Cubic and hexagonal Lattice arrangement.



Cubic Lattice Hexagonal Lattice

The de Broglie wavelength for a material particle is $\lambda = h/(m_e v_e)$. Where h is Planck’s constant (6.63×10^{-34} Js). For non-relativistic electrons KE << mc^2 therefore the electrons kinetic energy is equal to ½ $m_e v_e^2$, this energy is the result of the accelerating voltage V_a and is equal to eV_a.

Derive an equation for electron wavelength as a function of the accelerating voltage.

$$\lambda_e =$$

The circles that will be measured correspond to the transmitted diffraction maxima and are given for small angles by

$\lambda = d \sin \theta$ where θ is the angle by which the electron is bent, and is shown pictorially in Figure 2.

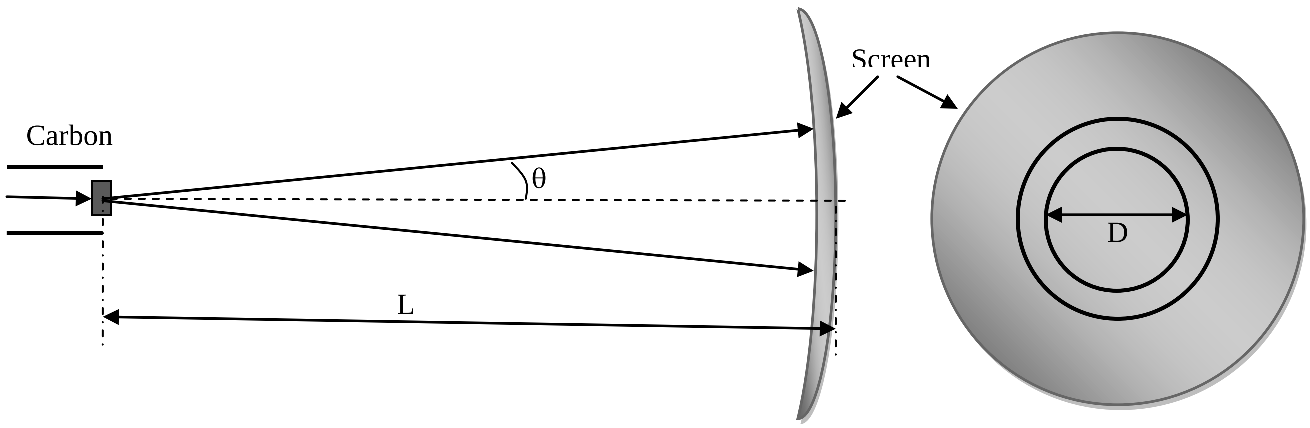


Figure 2

It should be noted that the screen has a radius of curvature R = 0.06 6± 0.002 m. For precise calculations this should be considered when determining the true value of D.

Taken from figure 2 $\sin \theta = D/(2L)$ therefore

$$\lambda = d\,(D/2L)$$

Where the length L is equal to 2R.

The variables to be controlled and measured in this experiment is the accelerating voltage V_a, and the diameter, D, of the diffraction pattern inner and outer circles.

Set the two equations for λ equal to one another rearrange it such that it would produce a linear function so that one variable can be plotted against the other to produce a linear line whose slope can be used to determine the value d.

The inner circle represents the diffraction created by the d_{10} lattice and the outer circle the pattern created by the d_{11} lattice.

Task 1. Setup the experiment.
Verify or make the following connections From the EHT power supply to the Universal Stand.

EHT Power supply	Universal Stand
+ 0-5kV	G7
– 0-5kV	A1
– 0-5kV	C5
6.3 VAC	F3
6.3 VAC	F4

Turn the voltage knob full counter clockwise and then turn on the power supply allow the filament to run for 1 minute before proceeding.

Task 2: Collecting data:
Turn the voltage to 2500 volts, observe the diffraction rings. For each applied voltage it is best to use a separate piece of tape voltage. Place a piece of masking tape across the tube surface, mark points so that the inside and outside diameter rings may be measured, label the tape with the applied voltage. Remove the tape. Repeat in increments of 500 volt steps up to and including 4500 volts. Use a Vernier caliper to measure the different diameters.

Task 3: Analysis
Plot the data according to the equation that you determined in the introduction. Determine the values for d_{10} and d_{11} for graphite. Also for each accelerating voltage determine the wavelength of the diffracted electron.