Electron Diffraction

Objectives:

- Generate electrons of different wavelengths
- Confirm the de Broglie hypothesis
- Observe Bragg diffraction from polycrystalline graphite
- Determine the d_{10} and d_{11} spacing in graphite

The wavelength of the electron that is accelerated through a potential difference of V volts is given by

$$\lambda = \sqrt{\frac{150}{V}} \quad \text{in Å}$$

Bragg's law of diffraction from planes of spacing d is given by $2\,d\sin\theta = \lambda$, where θ is the angle made by the electron waves with the planes.

Setup the electron diffraction setup using Tel-Atomic 555 electron diffraction tube and the necessary power supply. Check your circuit before turning on the power. You will see two diffraction rings on the fluorescent screen as shown in Fig. 1.Calculate the θ by the measured values of the ring radius (R) and the distance L using $\tan(2\theta) = R/L$. Measure the angle θ for various values of the accelerating voltages (at several values between 2.5 to 6.9 kV) and calculate d values for both inner and outer rings.

Alternately we can write the Bragg's law as (with small angle approximation $\Rightarrow \sin\theta \approx \theta$

$$2d\frac{R}{2L} = d\frac{D}{2L} = \sqrt{\frac{150}{V}} = \sqrt{150}\,V^{-1/2} \Rightarrow D = \frac{2L}{d}\sqrt{150}\,V^{-1/2}$$

Plot D vs. $V^{-1/2}$ and calculate the value of d from the slope of the graph using L = 13.5 cm

Compare the d values (for both the rings) determined by the two methods and with the expected values based on graphite crystal (see Fig. 2). What should the ratio of these two d values be for the hexagonal lattice? Check if your results agree with this dimensionless geometric fact.

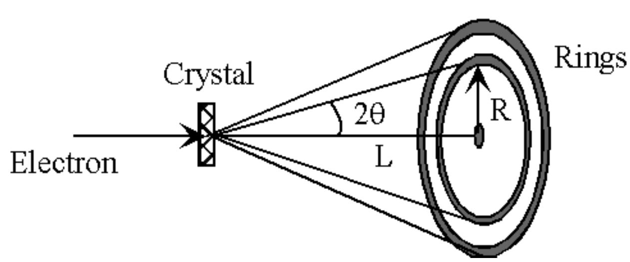
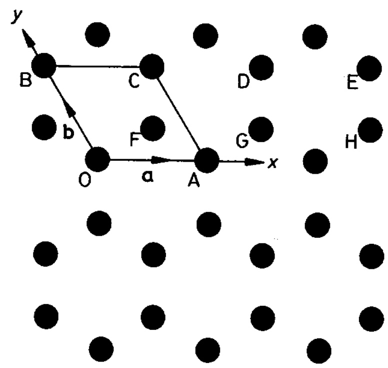
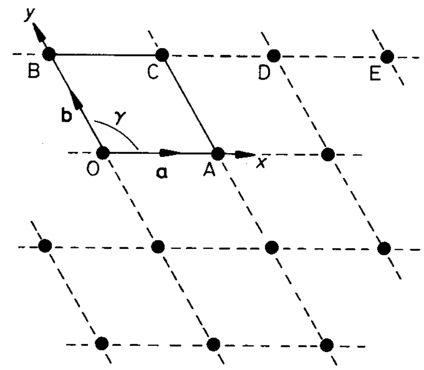


Fig. 1. Diffraction due to graphite



(a)



(b)

Fig. 2. Two-dimensional crystal of carbon atoms in graphite: (a) shows how the atoms are situated at the corners of regular hexagons; (b) shows the crystal lattice obtained by identifying all the atoms in (a) that are in identical positions to that at 0. The crystal axes, lattice vectors and conventional unit cell are shown in both figures. For graphite $a = b = 2.46$ Å and $\gamma = 120^o$.