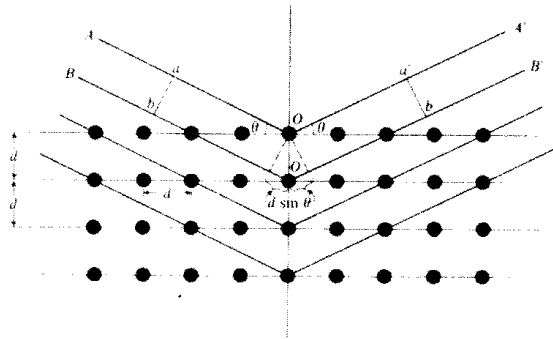


PHYS2180: Questions for Tutorial 9

Quantum effects

- Q1:** A small object of mass 1.00 mg is confined to move between two rigid walls separated by 1.00 cm. (a) Calculate the *minimum* speed of the object. (b) Is this speed measurable? (c) How much time would be required for the object to move 1 cm? Express your answer in units of universe lifetimes, 1 universe lifetime = 15×10^9 years = 47×10^{16} s.
- Q2:** We wish to simultaneously measure the wavelength and position of a photon. Assume that the wavelength measurement gives $\lambda = 6000 \text{ \AA}$ with an accuracy of one part in a million, i.e. $\Delta\lambda/\lambda = 10^{-6}$. What is the minimum uncertainty in the position of the photon?
- Q3:** Suppose Fuzzy, a quantum mechanical duck, lives in a world in which $\hbar = 2\pi \text{ J}\cdot\text{s}$. Fuzzy has a mass of 2.0 kg and is initially known to be within a region 1.0 m wide. (a) What is the minimum uncertainty in his speed? (b) Assuming this uncertainty in speed to prevail for 5.0 s, determine the uncertainty in position after this time.
- Q4:** An air rifle is used to shoot 1.0 g particles at 100 m/s through a hole of diameter 2.0 mm. How far from the rifle must an observer be to see the beam spread by 1.0 cm because of the uncertainty principle? Compare this answer with the diameter of the Universe ($2 \times 10^{26} \text{ m}$).

Sensors of structure



- Q5:** Considering the figure above and the two paths, AOA' and BO'B', show that for constructive interference we obtain the *Bragg law*

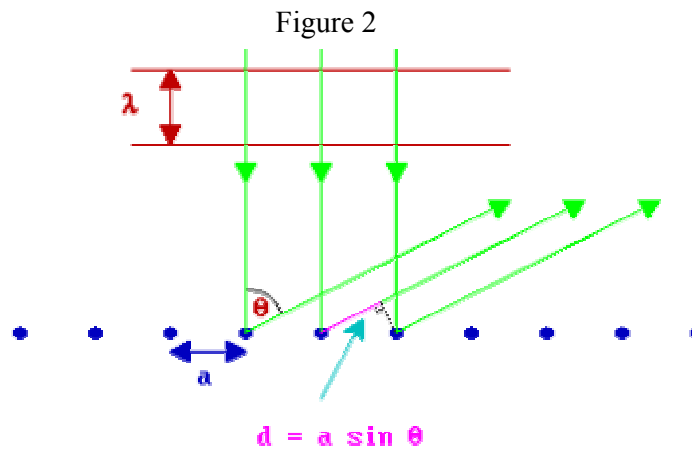
$$2d \sin \theta = n\lambda \quad (1)$$

where $n = 1, 2, 3, \dots$

- Q6:** X-rays can be used to sense stresses and structural changes in materials. (a) A 1 cm^3 cubic crystal of NaCl is illuminated with X-rays of wavelength 1.3922 \AA the first-order reflection of Bragg scattering of the X-rays is observed at an angle of 14.3° , calculate the lattice spacing. (b) A load of 359 N is applied to the crystal, what is the new average lattice spacing and (c) what is the new first-order reflection angle. (the density of NaCl is 2.163 g/cm^3 , Young's modulus for NaCl is about 34 GN/m^2).

Sensors of structure (Problem Sheet 9 - Continued)

Q7: The Davisson and Germer used low energy electrons to probe the structure of matter. Figure 2 shows the geometry of the set up.



If the angle measured in such an experiment was 50° and the spacing between the surface atoms of the surface 1.65 \AA . (a) What was the energy of the incident electrons and (b) the velocity of the electrons.