B.Sc Physics (Hons) Part II
Dr Satyadeo Narayan Singh
S.B. College, Ara

Q What do you meant by Quarter-wave and half-wave plate? Explain their use in the study of different types of polarised light?

Ans **Quarter wave plate:**

A double refracting crystal plate which has a thickness such that to produce a path difference of $\lambda/4$ or a phase difference of $\lambda/2$; between the O-ray (ordinary) and E-ray (extra ordinary) is known as quarter wave plate or $\frac{\lambda}{4}$ plate.

Considering a plane parallel plate cut from a double refracting crystal so as to have its faces to the optic axis. Let a beam of monochromatic light of wavelength λ be incident normally on the plate. It is broken up to E and O waves.

According to Huygen's construction for double refraction, both the waves travel along the same path normal to faces but with different velocities. In case of a (-ve) crystal like Calcite the E-ray travels faster than the O-wave, so that $\mu_o > \mu_e$. Here μ_o & μ_e are refractive indices of the crystal for the O and E waves.

If 't' be the thickness of the plate and optical path's of these waves in the plates are $\mu_o t$ & $\mu_e t$, So that the path difference between the two waves on emerging is $(\mu_o - \mu_e)t$

If the plate is act a quarter wave plate, this path difference should be equal to $\lambda/4$, i.e

$$(\mu_o - \mu_e)t = \lambda/4 \quad \text{or} \quad t = \frac{\lambda}{4(\mu_o - \mu_e)}$$

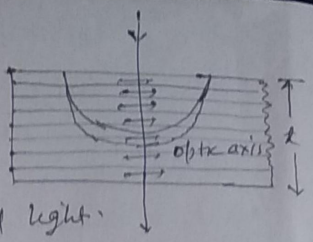
In case of (+ve) crystal like Quartz $\mu_e > \mu_o$ so that

$$t = \frac{\lambda}{4(\mu_e - \mu_o)}$$

Here a plate thickness is given by this equation will serve as quarter wave plate for the particular wavelength λ.

If the quarter wave plate is used for

producing circularly and elliptically polarised light. In conjunction of a Nicol prism, it is used for analysing all types of polarised light.



Half wave plate :→

In this type of doubly refracting crystal thickness is such as to produce a path difference of $\lambda/2$ or phase difference of π between the ordinary and extra ordinary waves is known as half wave plate or $\frac{\lambda}{2}$ plate.

If thickness 't' of such a plate for a (-ve) crystal like calcite,

$$(\mu_o - \mu_e)\, t = \lambda/4$$

$$\therefore\ t = \frac{\lambda}{4(\mu_o - \mu_e)}$$

If linearly polarised light is allowed to pass through a $\frac{\lambda}{2}$ plate, the emergent light is also linearly polarised but its ~~diffraction~~ direction of vibration is inclined at 2θ so that in the incident light, where θ is the angle between the incident vibration and the principle section of the plate, so this type of plate is used in polarimeter as half shade devices to divide the field of view into two half halves presented side by side $\frac{\lambda}{4}$ and $\frac{\lambda}{2}$ plates are often made either of quartz by cutting it parallel to the optic axis or by splitting thin sheets of mica along cleavage between two axes is very small.

Quartz is a positive crystals and has got no cleavage planes. So it has to be cut and its faces have to ~~polarised~~ polished to make them optically plane.