QUARTER WAVE PLATE
&
HALF WAVE PLATE

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Quarter Wave Plate:

A uniaxial doubly refracting crystal cut with its faces parallel to the optic axis which can introduce a phase difference of Π/2 or a path difference of λ/4 between the ordinary and extraordinary rays is called a Quarter wave plate.

When a beam of plane polarised of wavelength λ is incident normally on it , it is split up into O-ray and E-rays . They travel with different velocities in same direction. In case of negative crystals such as calcite E-rays travels faster than O-ray . So $\mu_0 > \mu_E$.

If t is the thickness of the plate then the distance travelled in the crystal by the O-ray and E-rays is equal to $\mu_0 t$ & $\mu_E t$ in air .

∴ Resultant path difference = $\mu_0 t - \mu_E t$

In this quarter wave plate path difference between O-rays and E-rays is equal to $\lambda/4$.

$$(\mu_0 - \mu_E)\, t = \lambda/4$$

$$t = \lambda / 4(\mu_0 - \mu_E)$$

where t is the thickness of the Quarter wave plate .

For a positive crystals like Quartz , $t = \lambda / 4(\mu_E - \mu_0)$

A quarter wave plate is used for producing and detecting circularly polarised light. If the plane polarised light whose plane of vibration is inclined at an angle of 45° to the optical axis is incident on a quarter wave plate , the emergent beam is circularly polarised.

Half Wave Plate:

This plate is also made from a doubly refracting uniaxial crystal of Quartz or Calcite with its refractive faces cut parallel to the optic axis. The thickness of the plate is such that the O-ray and E-rays have a path difference equal to $\lambda/2$ after passing through the crystal.

Path difference of O-ray and E-ray = $(\mu_0 - \mu_E)\,t$ for negative crystals.

But in case of half wave wave plate path difference = $\lambda/2$

$$\therefore \quad (\mu_0 - \mu_E)\,t = \lambda/2$$

$$\Rightarrow \quad t = \lambda / 2(\mu_0 - \mu_E)$$

where t is the thickness of the half wave plate.

For positive crystals $t = \lambda / 2 (\mu_E - \mu_0)$

When plane polarised is incident on a Half wave plate such that it makes an angle of 45° with the optic axis.

A path difference of $\lambda / 2$ is introduced between E & O rays the emergent light is plane polarised and the direction of polarisation of incident light is rotated to 90°.