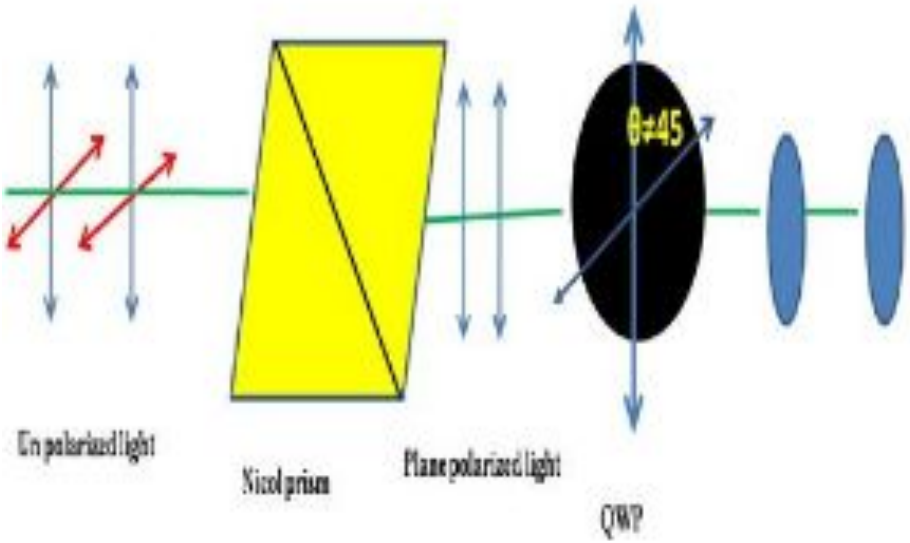
DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

18PYB101J -Electromagnetic Theory, Quantum Mechanics, Waves and Optics

Module-IV (Waves and Optics) Lecture-14

Elliptical polarization – Production and detection and Optical Activity - Quarter Wave And Half Wave Plates

Production of Elliptically polarized light



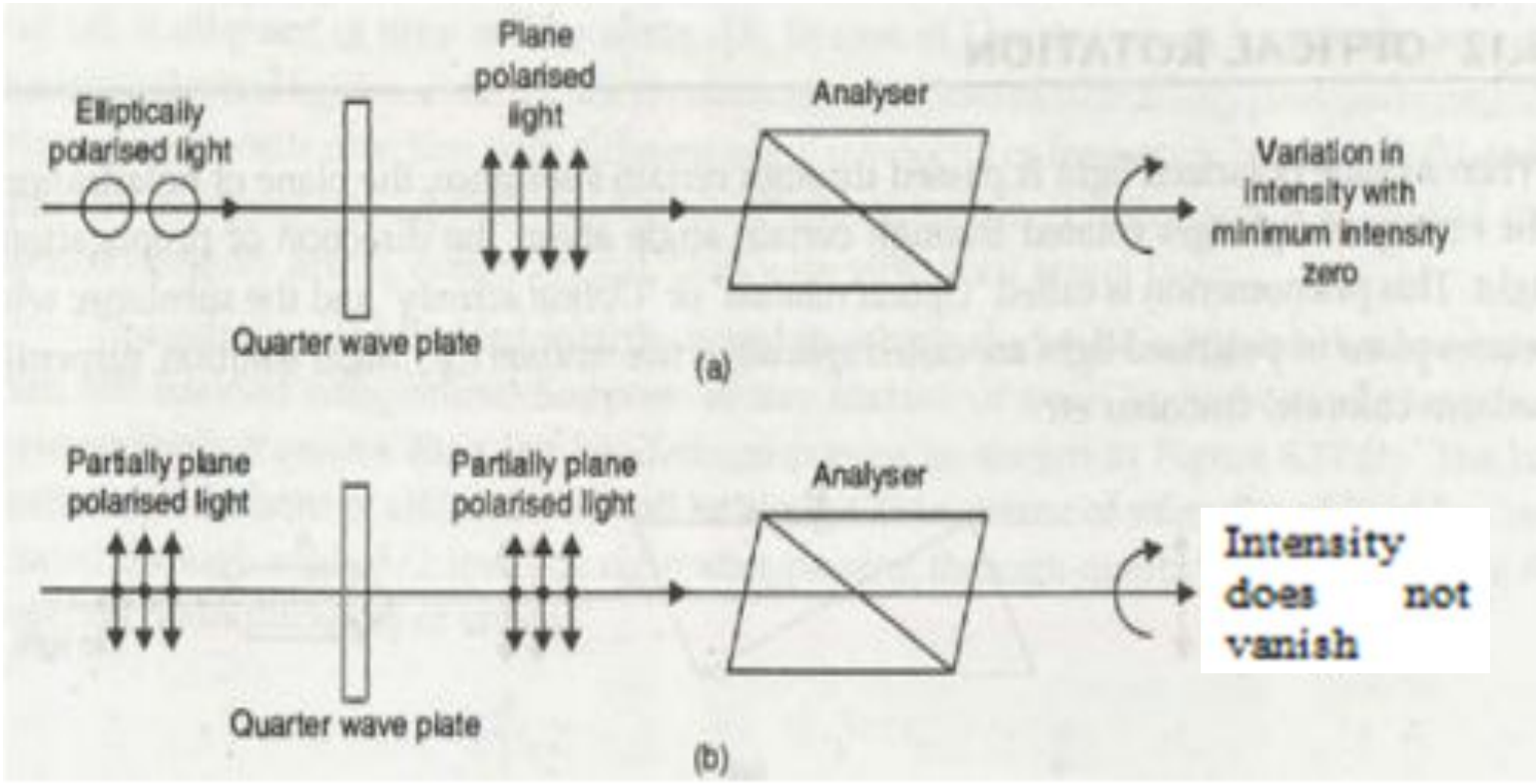
- Unpolarised light ➡ Nicol prism ⇔ Plane polarized light
- vibration in the incident light making an angle, $\theta \neq 0, 45, 90$ degree with the optic axis of QWP.
- ➡ elliptically polarized light

- Unpolarized light is first converted to plane polarized light by allowing it to pass through a polarizer.

- The polarizer and QWP are rotated such that the electric vector E of the plane polarized wave makes an angle of θ is not equal to 45^{o} with the optic axis of QWP, the plane polarized wave incident on QWP splits into two rays O-ray and E-ray of equal amplitude.

- The two rays are in phase at the front face of the crystal but progressively get out of phase as they travel through the crystal. As they emerge from the rear face of the crystal, they will have a path difference of $\lambda/4$ or phase difference of 90^o.
- The two rays are linearly polarized in mutually perpendicular directions. When they combine, they produce elliptically polarized light.

Detection of Elliptically polarized light



- The elliptically polarized light beam is allowed to pass through the rotating analyzer, the intensity of the emerging beam varies from maxima and minima, then the incident is elliptically polarized light. Similar result would be obtained if the incident light is unpolarized light.

- To distinguished between these two cases, by introducing the QWP in the path of light before it falls on the analyzer.

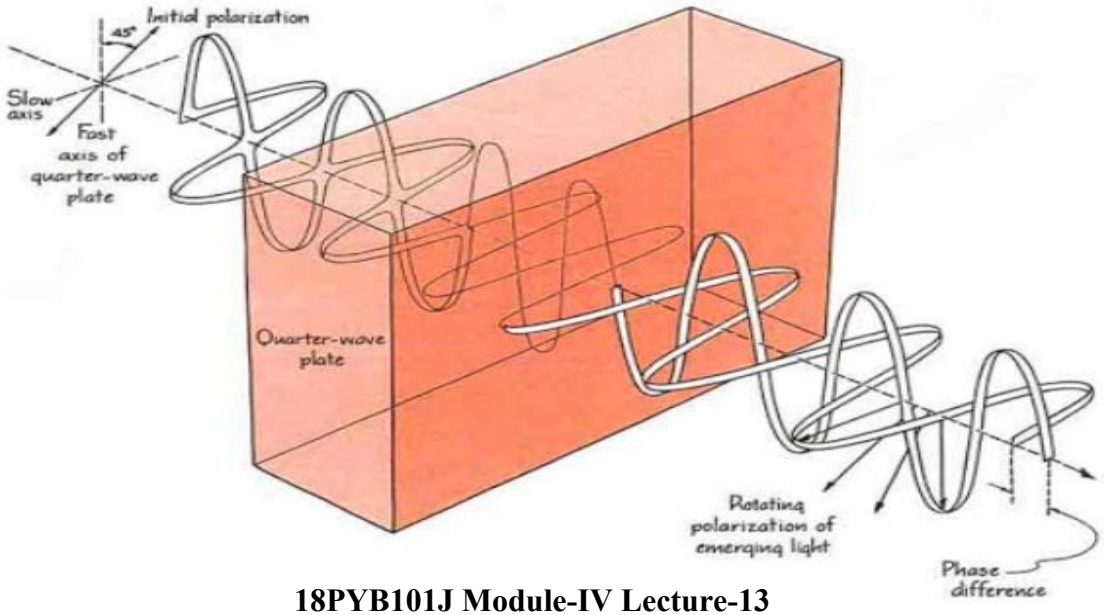
- If the light passes through the QWP, an additional path difference of 90^o is introduced between O-ray and E-ray. Therefore the total phase difference of 180^o between O-ray and E-ray. On emerging from the QWP, the O-ray and E-ray combine to produce plane polarized light.

- Therefore if light coming out of QWP is examined with an analyzer, light will be extinguished twice in one full rotation of the polarizer.

Quarter Wave And Half Wave Plates

Quarter Wave Plate:

A quarter wave plate is a thin plate of birefringent crystal having the optic axis parallel to its refracting faces and its thickness adjusted such that it introduces a quarter wave of Path difference $\lambda/4$ and phase difference $\pi/2$ between the extra ordinary ray and ordinary ray propagating through it.



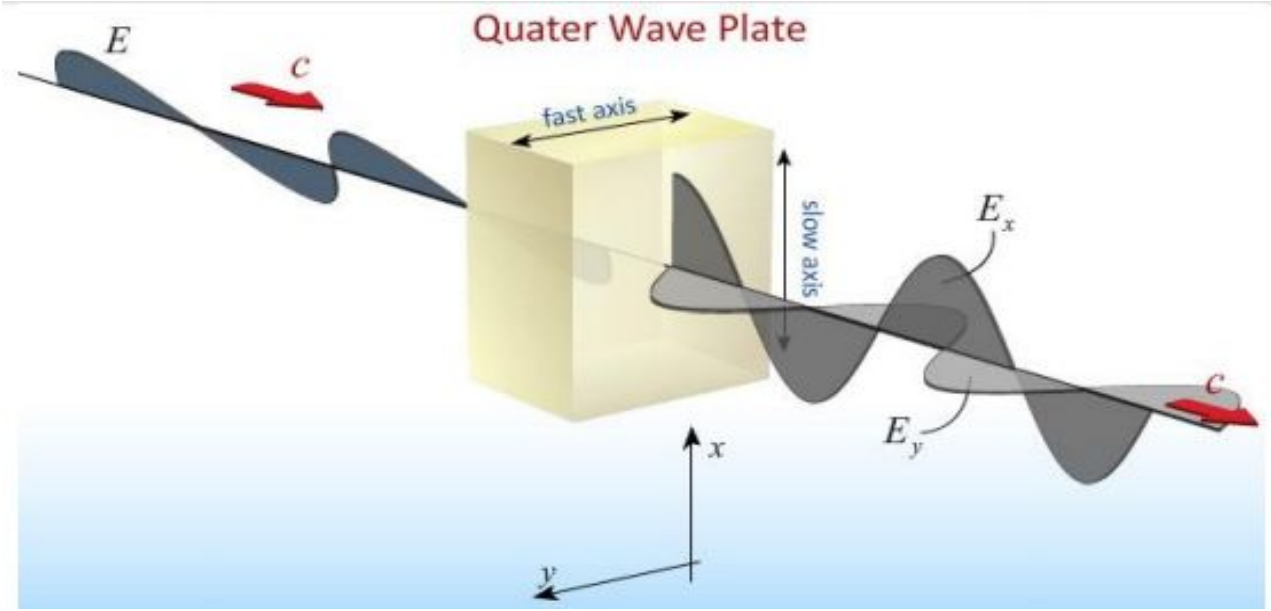
- When a plane polarized light wave is incident on a birefringent crystal having the optic axis parallel to its refracting surface, the wave split into O ray and E ray.

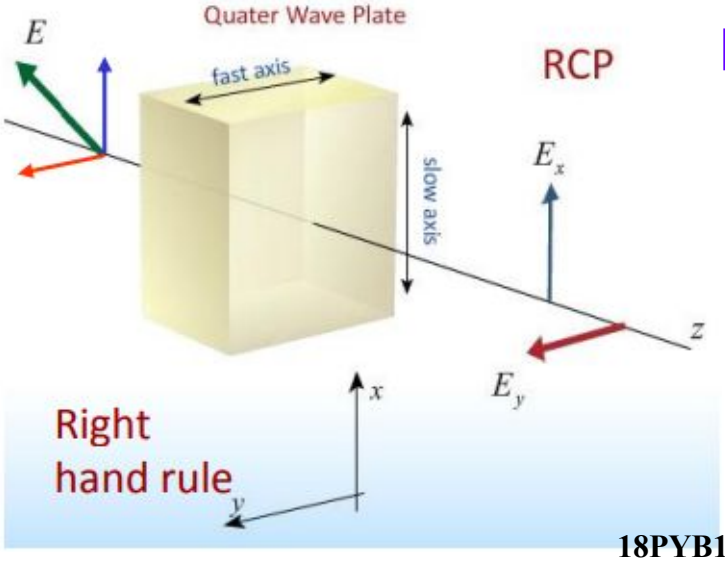
- As a result, when they emerge from the rear face of the crystal an optical path difference ($\lambda/4$) would be developed between them.

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

$$d = \frac{\lambda}{4[\mu_e - \mu_o]}$$

Where μ_e , μ_o are the refractive index of E and O Ray and d is the thickness of the wave plate.

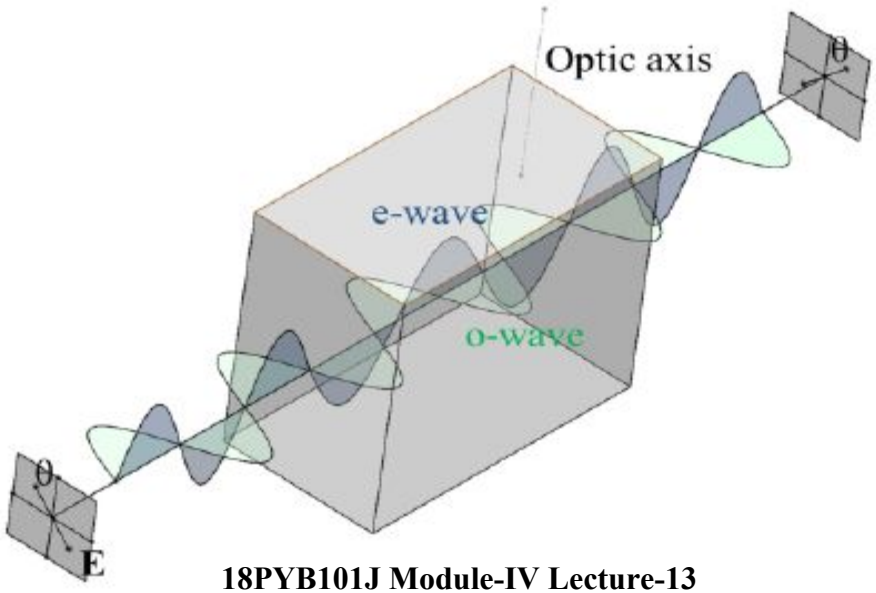




- By picking the right thickness (d) we can change the relative phase by exactly 90°. This changes linear to circular polarization.
- A quarter wave plate is used in producing **circularly** or **elliptically** polarized light.

Half Wave Plate

A Half wave plate is a thin plate of birefringent crystal having the optic axis parallel to its refracting faces and its thickness adjusted such that it introduces a half wave of path difference $\lambda/2$ and phase difference π between the extra ordinary ray and ordinary ray propagating through it.



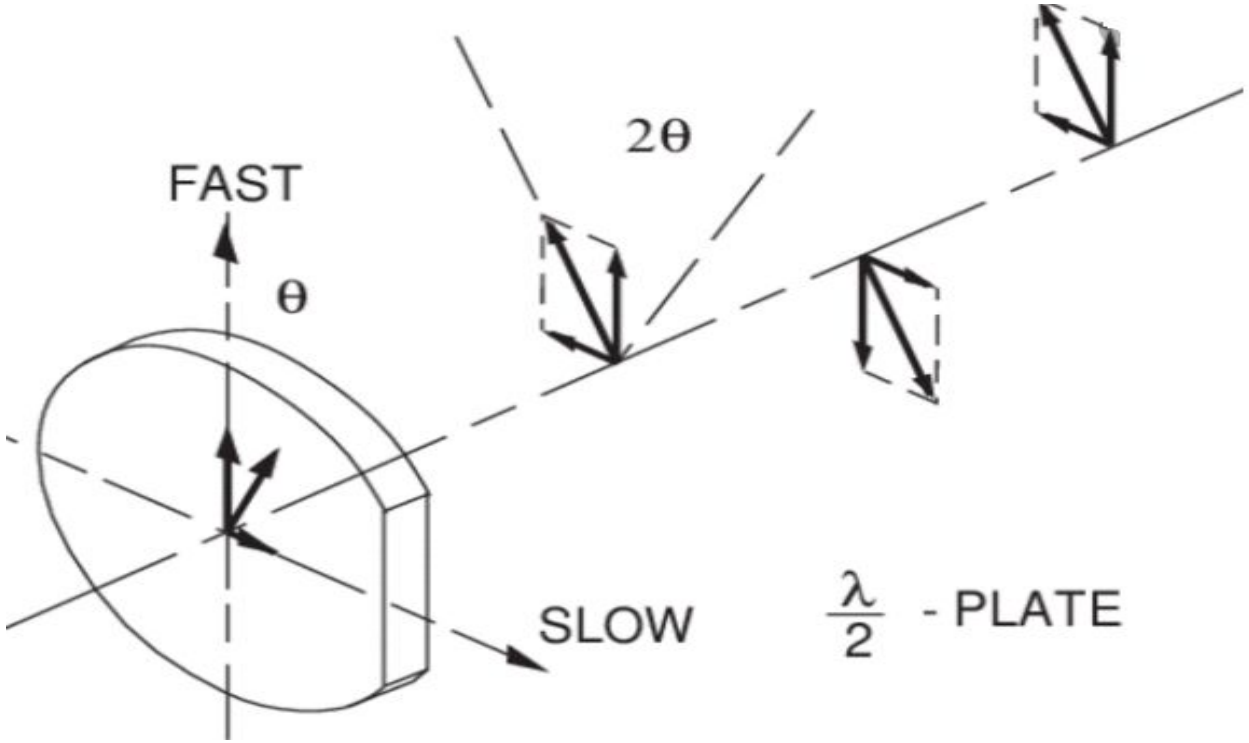
- When a plane polarized light wave is incident on a birefringent crystal having the optic axis parallel to its refracting surface, the wave split into E-wave and O-wave.

- As a result, when they emerge from the rear face of the crystal an optical path difference ($\lambda/2$) would be developed between them.

$$(\mu_e - \mu_o)d = \frac{\lambda}{2}$$

$$\boxed{d = \frac{\lambda}{2(\mu_e - \mu_o)}}$$

Where μ_e , μ_o are the refractive index of E and O Ray and d is the thickness of the wave plate.



- A half wave plate is used for changing the direction of plane of vibration of plane polarized light. When light is incident normally on half wave plate, the plane of vibration of emergent ray rotates through an angle 2θ.
- A half wave plate is used in producing **circularly** or **elliptically** polarized light.