Nicol prism & Production of circularly polarised light:

For producing plane polarised light, a beam of ordinary light is sent through a Nicol prism in a direction almost parallel to the long edge of the prism. The beam is broken up into two components inside the prism. The ordinary component is totally reflected at the Canada Balsam layer and it is absorbed. The E-component emerges out. It is plane polarised light with its vibration parallel to the shorter diagonal of the end face of the Nicol.

For detecting the plane-polarised light it is examined through another Nicol prism rotating about the direction of propagation of light. If the intensity of the emerging light varies with zero minimum, the light is plane polarised.

→ Production of circularly polarised light → This type of light may be produced by allowing plane-polarised light obtained from a Nicol prism to fall normally on a quarter wave plate. Such that the direction of vibration in the incident plane polarised light makes an angle of 45° with the optic axis of the plate.

In the inner of plate the incident wave of amplitude (A) is broken into an E component $A\cos 45°$ parallel to the optic axis and an O component $A\sin 45°$ Lr. to the optic axis. These components emerge from the plate with a phase difference of $\frac{\pi}{2}$.

Let us take $A\cos 45° = A\sin 45° = a$. If the axes of x & y be taken along and normal to the optic axis, then the emerging components may be written as

$$x = a\sin\left(\omega t + \frac{\pi}{2}\right) = a\cos\omega t \quad \text{—— (1)}$$

$$y = a \sin \omega t \quad --- (2)$$

on eliminating t from (1) & (2), the resultant vibration is

$$x^2 + y^2 = a^2$$

This represent a circle. So the light emerging from the quarter wave plate is circularly polarised. The circularly polarised light when seen through a rotating Nicol, shows no variation in intensity. It so resembles unpolarised light. So to confirms that the given light is circularly polarised it is first passed through out a $\frac{\lambda}{4}$ plate and then through the rotating Nicol. The light now shows a variation in intensity with zero minimum.

Production of Elliptically polarised light →

This type of light may be produced by allowing plane polarised light received from a Nicol prism to fall normally on a quarter wave plate such that the direction of vibration in incident plane polarised light makes an angle other than 0°, 45° & 90° with the optic axis of the plate. An appropriate angle is 30°.

Inside the plate, incident wave is divide into E and O components of unequal amplitudes $A \cos 30°$ and $A \sin 30°$ respectively which emerges from the plate with a phase difference of $\frac{\pi}{2}$.

let us take $A \cos 30° = a$

$A \sin 30° = b$

So the emerging components may be expressed as:

$$x = a \sin\left(\omega t + \frac{\pi}{2}\right) = a \cos \omega t$$

$y = b \sin \omega t$

eliminating 't' we get :

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

This represents an ellipse. Hence the light emerging from the $\frac{\lambda}{4}$, plate is elliptically polarised.

Detection of Elliptically polarised light → When this light seen through a rotating Nicol indicates variation in intensity but the minimum intensity is not zero. It resembles partly plane polarised light. So to confirms that the given light is elliptically polarised, it is first examined through a rotating Nicol and the Nicol is adjusted for maximum intensity. The principal section of the Nicol is now parallel to the major axis of the elliptic vibration.

Another $\lambda/4$, Plate is now introduced between the first plate and the Nicol such that the optic axis of the second plate is parallel to the principal section of the Nicol. The optic axis of the plate thus becomes parallel to the major axis of the elliptic vibration. The light after passing through the second $\frac{1}{4}$ plate becomes plane - polarised. If the Nicol be now rotated the intensity will vary with zero minimum.

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