Production and detection of Plane, Circularly and elliptically Polarised light.

Production of Plane Polarised light

For producing plane Polarised light, a beam of ordinary light is passed through a nicol Prism, it splits up into two Components - E-ray and O-ray. The O Component is totally reflected at Canada balsam layer and is absorbed by the sides of the tube Containing the nicol. The E Component Passes through the Nicol Prism & emerges out. The emergent beam is plane Polarised.

Detection: To detect Plane Polarised light, it is allowed to Pass through another Nicol Prism rotating about the direction of Propagation of light. If the intensity of emergent light varies and vanishes twice in each rotation, then it is plane Polarised.

Production of Circularly Polarised light

It is produced by allowing Plane Polarised light to fall normally on a quater waveplate such that the vibrations in the incident light make an angle of 45° with optic axis of the Plate. In this case the incident light is divided into E and O Components of equal amplitude $A\cos 45°$ and $A\sin 45°$.

Let $A\cos 45° = A\sin 45° = a$. As the quarter wave Plate introduces a Phase difference of $\pi/2$, the two components may be written as

$$x = a\sin(\omega t + \pi/2) = a\cos\omega t \quad \& \quad y = a\sin\omega t$$

The resultant vibration is therefore given by
$x^2+y^2=a^2$ which represents a circle.
Hence the light emerging from $\lambda/4$ Plate is Circularly Polarised.

Detection : The circularly Polarised light when seen through a rotating nicol Prism shows no variation. In this respect it resembles unpolarised light. Hence to detect circularly Polarised light it is first pass normally through a $\lambda/4$ Plate (which converts it into a Plane Polarised light) and then through a nicol. If the light vanishes twice in each rotation of nicol Prism then it is circularly Polarised light otherewise it is unpolarised.

Production of elliptically Polarised light

The elliptically Polarised light is produced by sending plane Polarised light normally through quarter wave plate and that the direction of vibration in the incident light makes an angle θ with the optic axis of the Plate.
Let A be the amplitude of vibrations of the incident light. Inside the plate, the light is divided into two plane Polarised waves, one wave parallel to the optic axis (E wave) and other ⊥r to the optic axis (O-wave). The amplitudes of E and O waves will be $A\cos\theta$ and $A\sin\theta$ respectively. The Phase difference at the Point of entering is zero and at the Point of emergence is $\pi/2$.

let $A\cos\theta = a$ and $A\sin\theta = b$. If the axes of x & y are taken along & ⊥r to the optic axis, then the equations of E and O waves may be written as

$$x = a\sin(\omega t+\pi/2) = a\cos\omega t \quad \& \quad y = b\sin\omega t$$

Eliminating t in the above two equations, we get the equation of resultant vibration as

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

This equation represents an elliptic vibration, hence the emergent light is in general elliptically Polarised light. However when $\theta = 0$, $b = 0$ and the emergent light is Plane Polarised with the vibration Parallel to the optic axis. When $\theta = 90°$, $a = 0$ and the emergent light is Plane Polarised with vibrations ⊥r to the optic axis. When $\theta = 45°$, $a = b$ and the resultant vibration is Circular so that the emergent light is Circularly Polarised.

Hence in order to produce elliptically Polarised light θ must be different from $0°$, $45°$ & $90°$.

Detection: If the light is incident on a Nicol Prism and the intensity varies from a Maximum to a minimum then the light is either elliptically Polarised or a mixture of Polarised and unpolarised light.

Now, the light is made to fall on a quarter wave plate and then on a rotating Nicol Prism. If the light vanishes twice each rotation of the Nicol Prism, it is Polarised elliptically otherwise it is a mixture of Polarised light + unpolarised light.