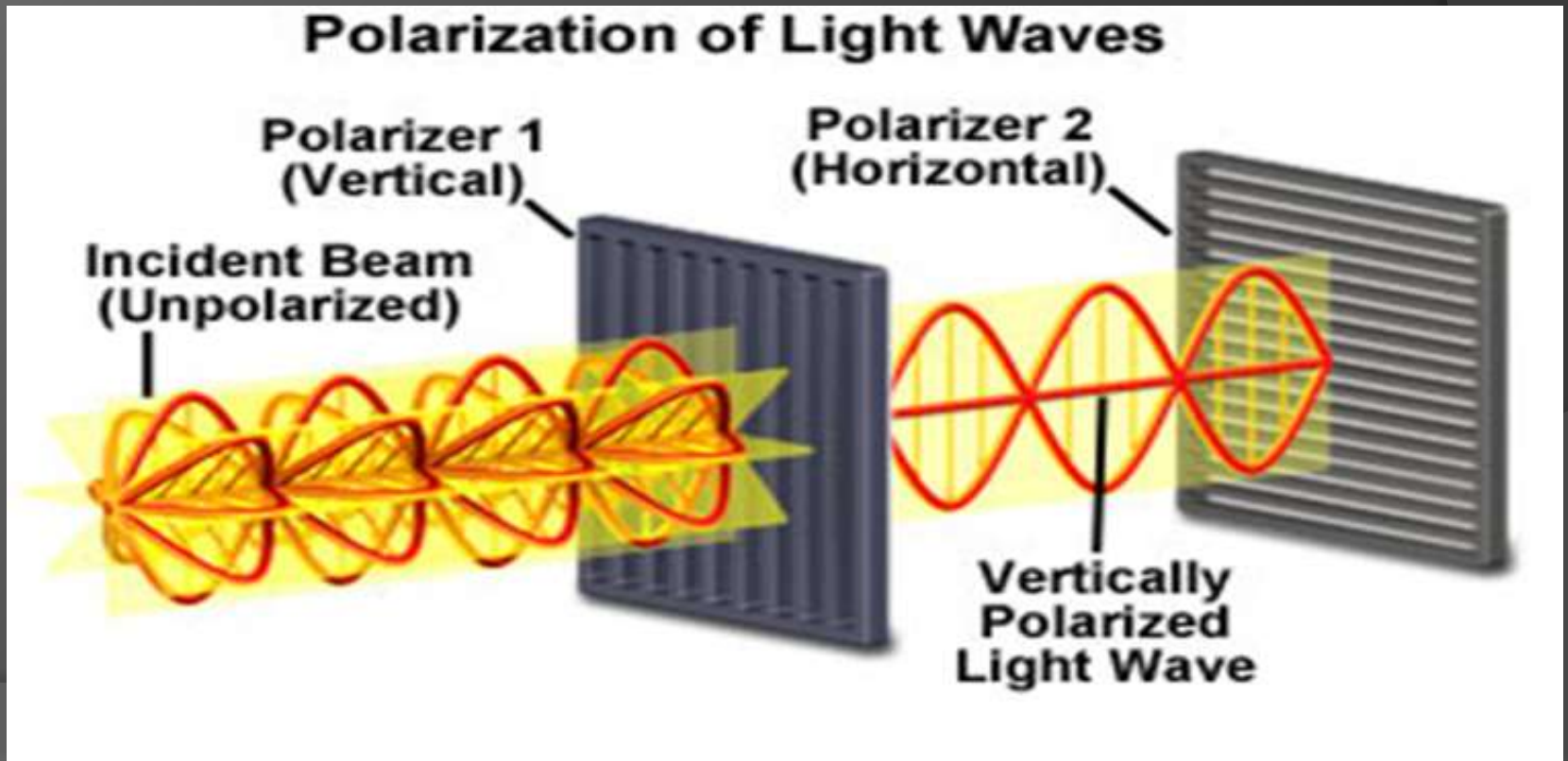
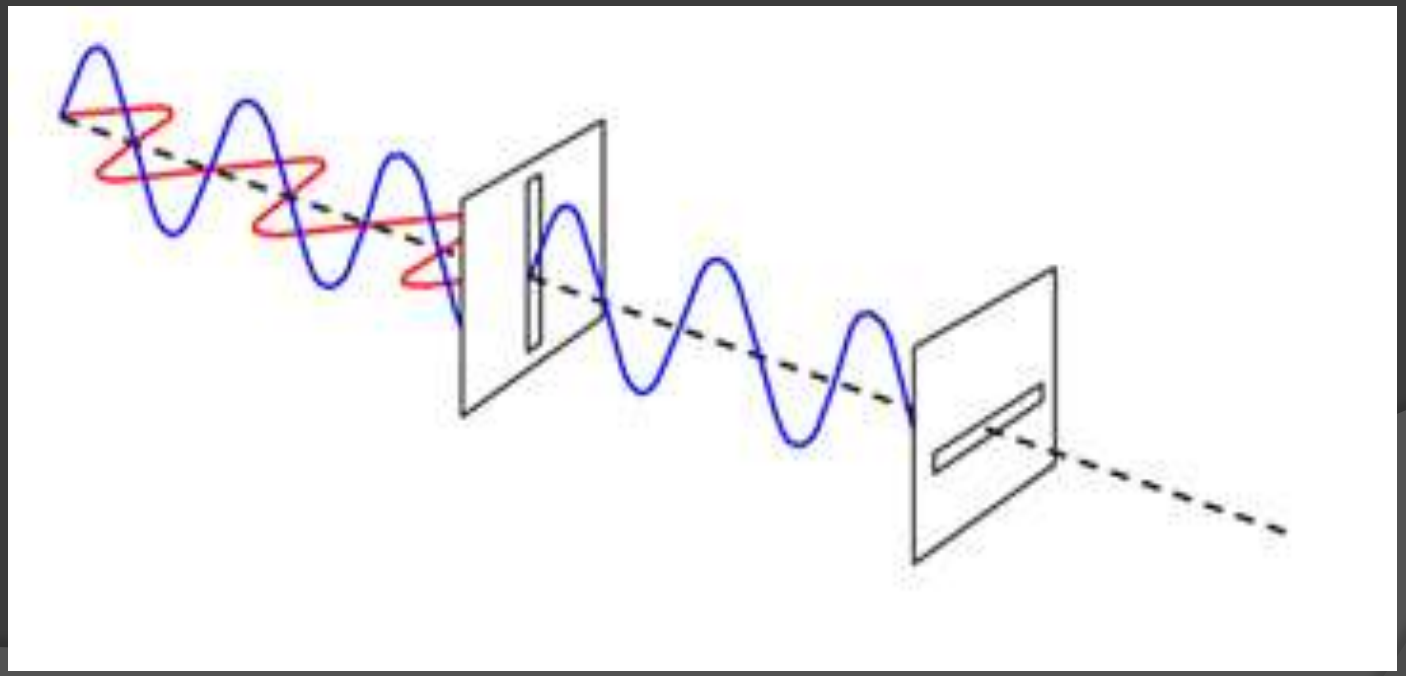
DEFINITION

If the vibration of light are confined in a definite direction or directions by any means,then this state of light is called '**polarized light**' and this phenomenon is called '**polarization of light**'.



PROPERITY

- Only transverse wave can show this this properity of light.

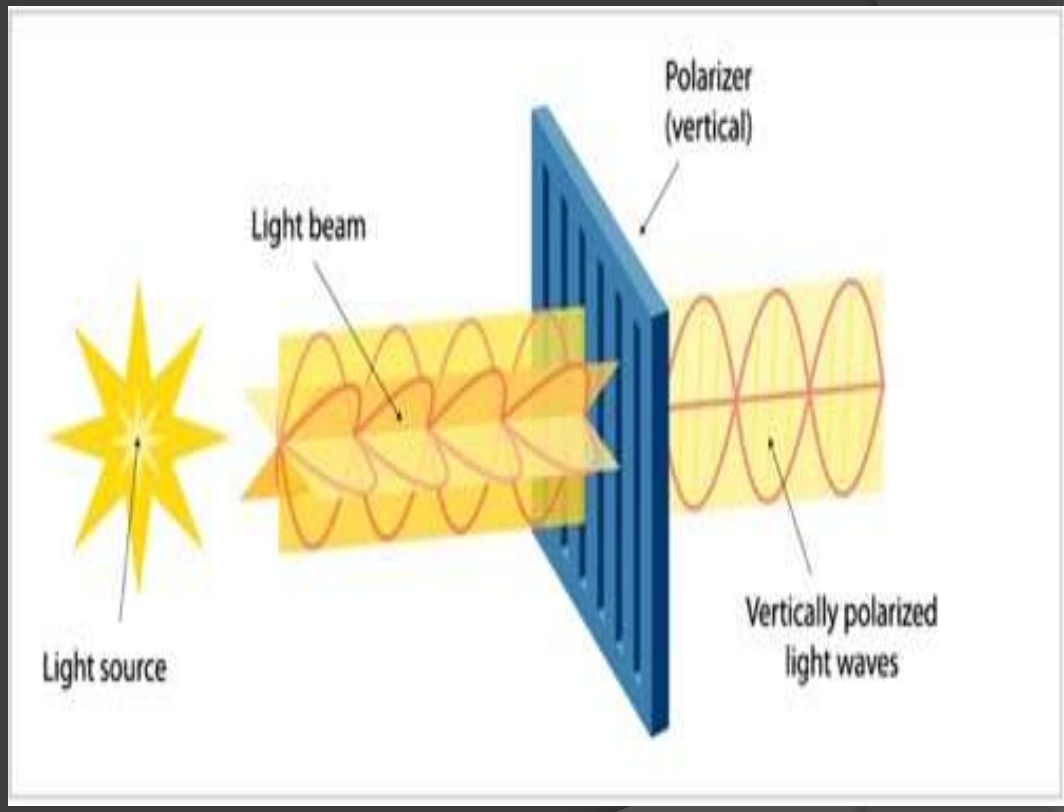


There are three type of polarized light

1) Plane Polarized Light (ppl or lpl)
2) Circularly Polarized Light (cpl)
3) Elliptically Polarized Light (epl)

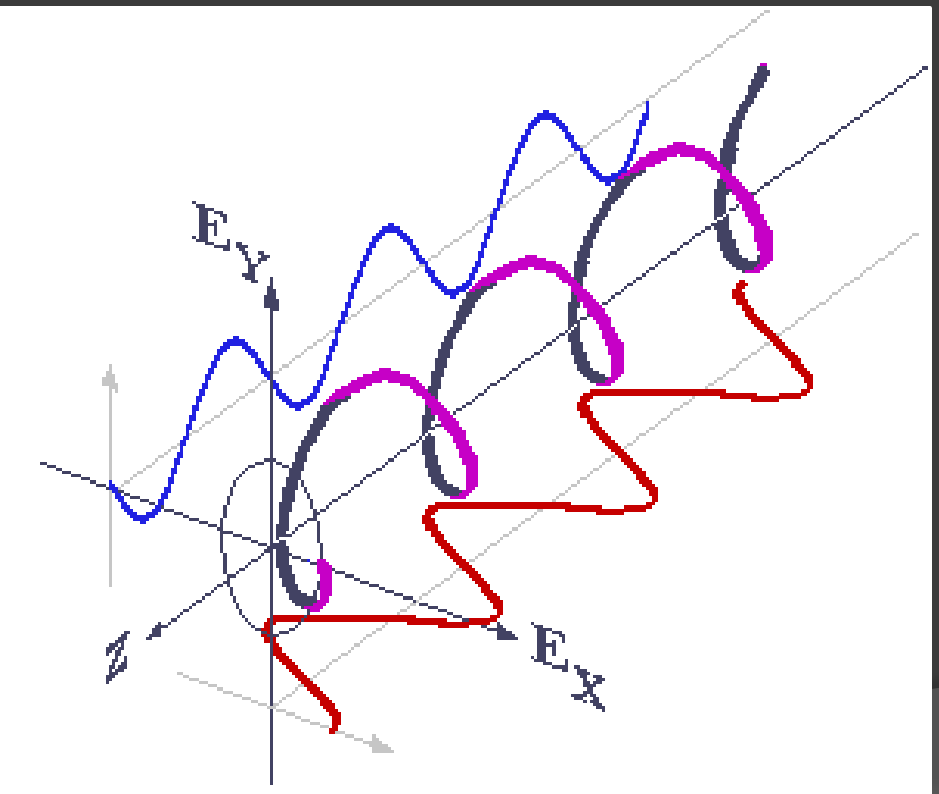
1)PLANE POLARIZED LIGHT

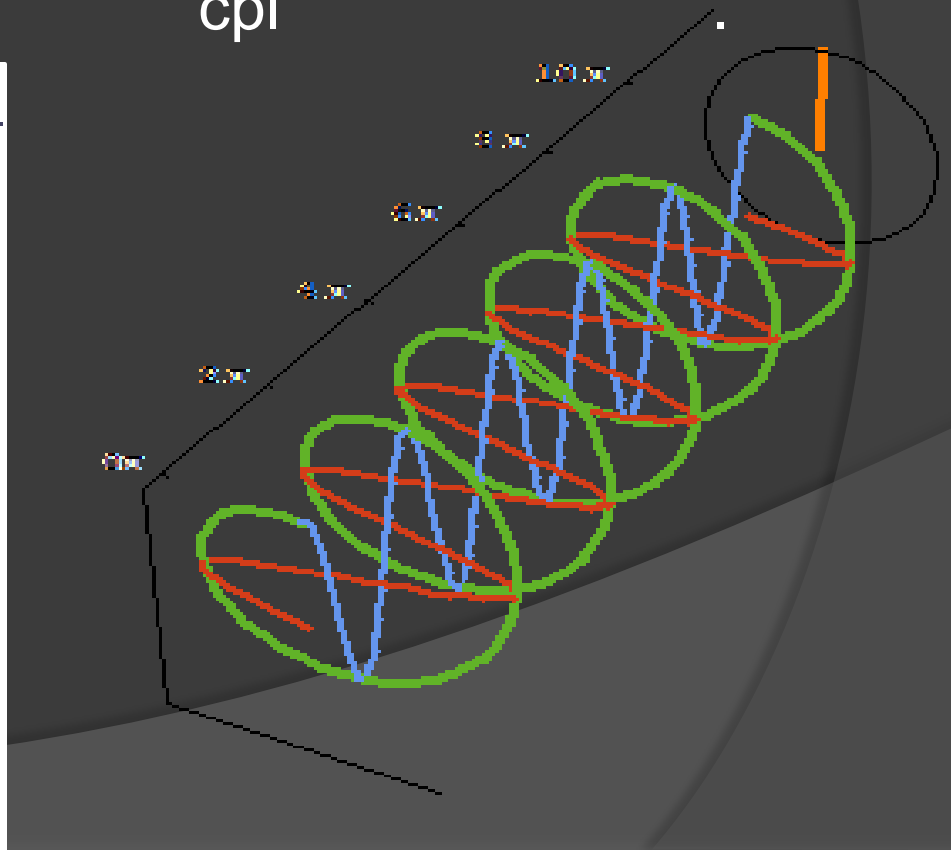
- If the vibration of light are confined in a definite plane to the direction of propagation with respect to time,then light is called ‘ppl’or ‘lpl’.



2) CIRCULARLY POLARIZED LIGHT

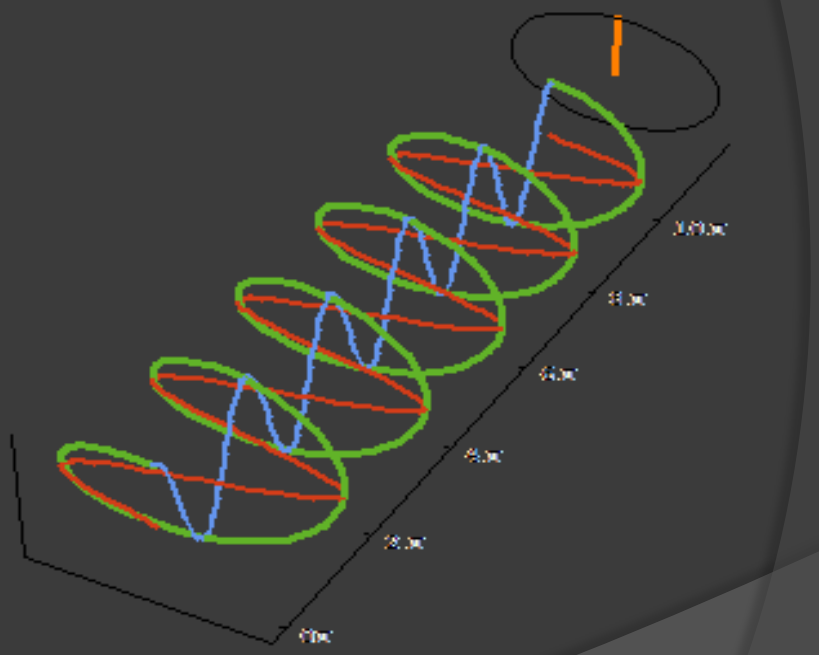
On the superposition of two ppl (having equal amplitude & phase difference of ´/2) if the magnitude of resultant light vector remains constant while it's orientation varies regularly w.r.t time then this resultant light is 'cpl' .





3) **ELLIPTICALY POLARIZED LIGHT**

On the superposition of two ppl(having different amplitude&phase diffference of ´/2)if the magnitude &orientation of resultant light both vary w.r.t time then this resultant light is ‘epl’.

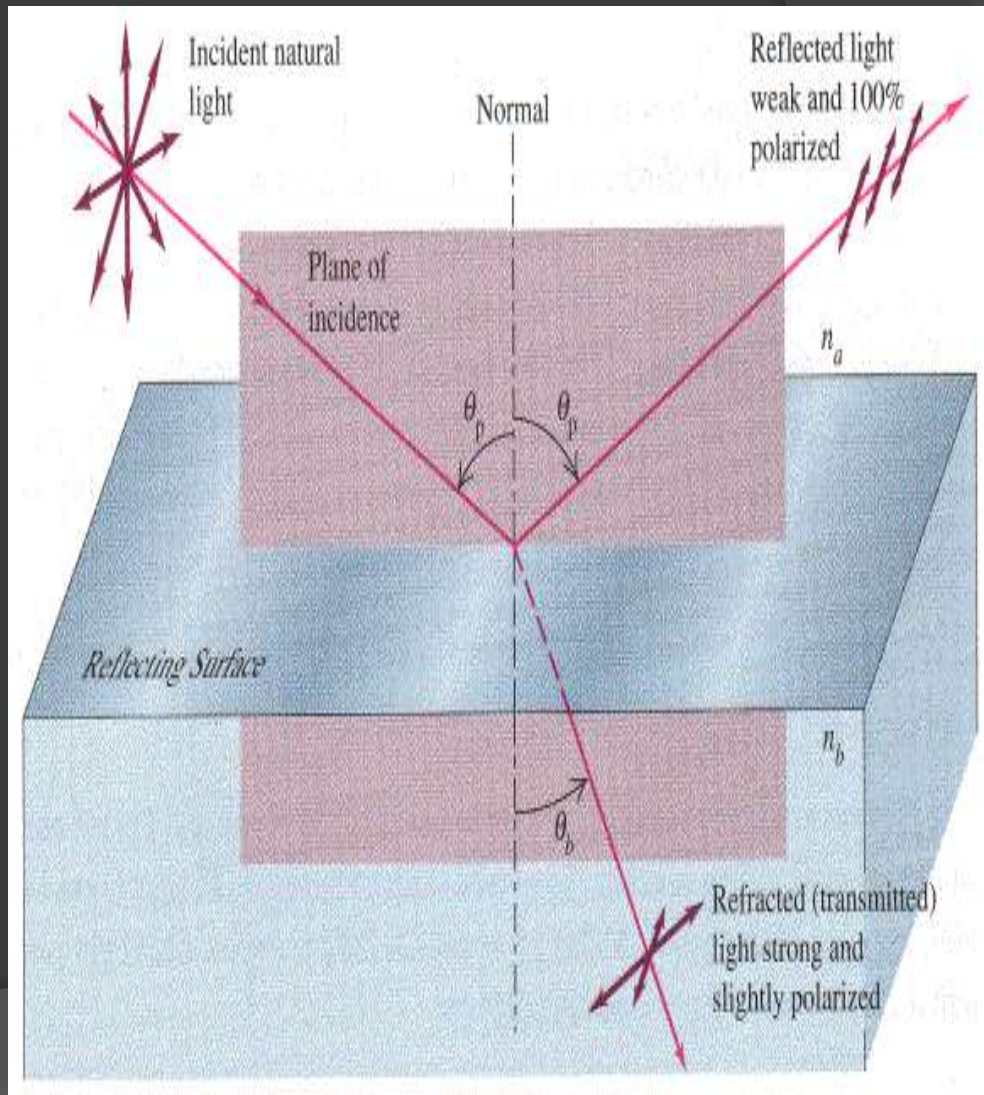


PRODUCTION OF PPL

1) By Reflection
2) By Refraction
3) By Selective Absorption(Dichroizm)
4) By Scattering
5) By Double Reflection

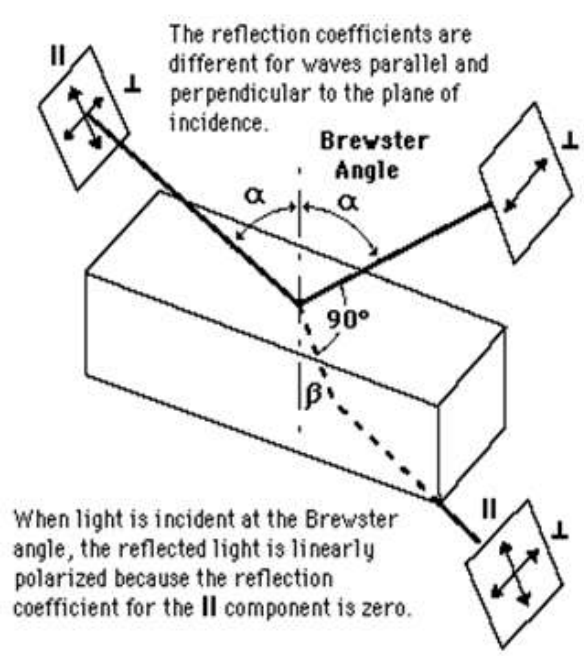
1) PPL BY REFLECTION

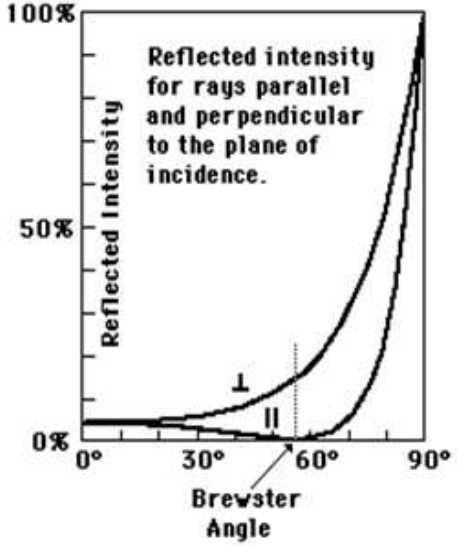
- When an unpolarized light is reflected from the surface of a transparent medium such as water , glass etc. then the reflected light is partially polarized.

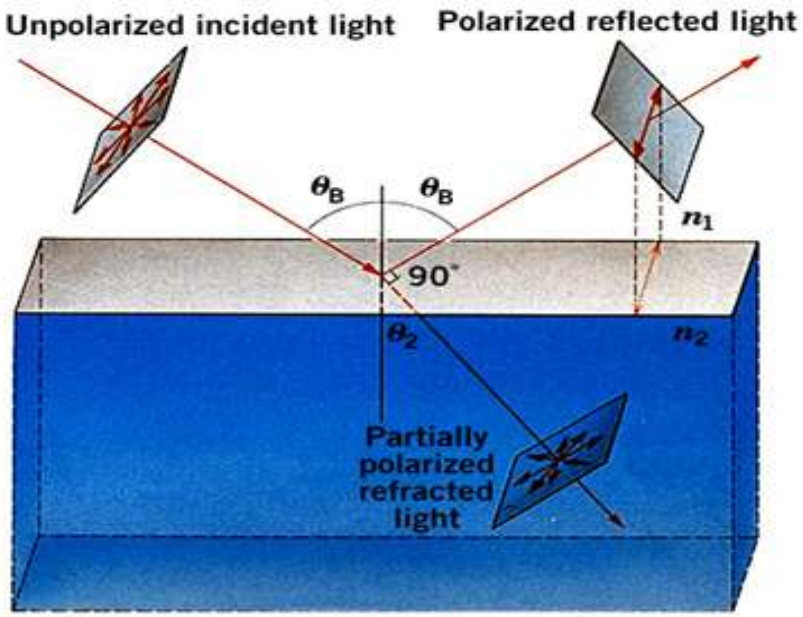


BREWSTER's LAW

- Brewster states that "the tangent of the polarization angle'θ_B' is equal to the refractive indux 'μ' of the refractive medium w.r.t its surrounding medium". We also find that the reflected and the refracted rays are perpendicular to each other. { $\mu=\tan\theta_B$ } {$\theta_B+\theta_2=90^o$}

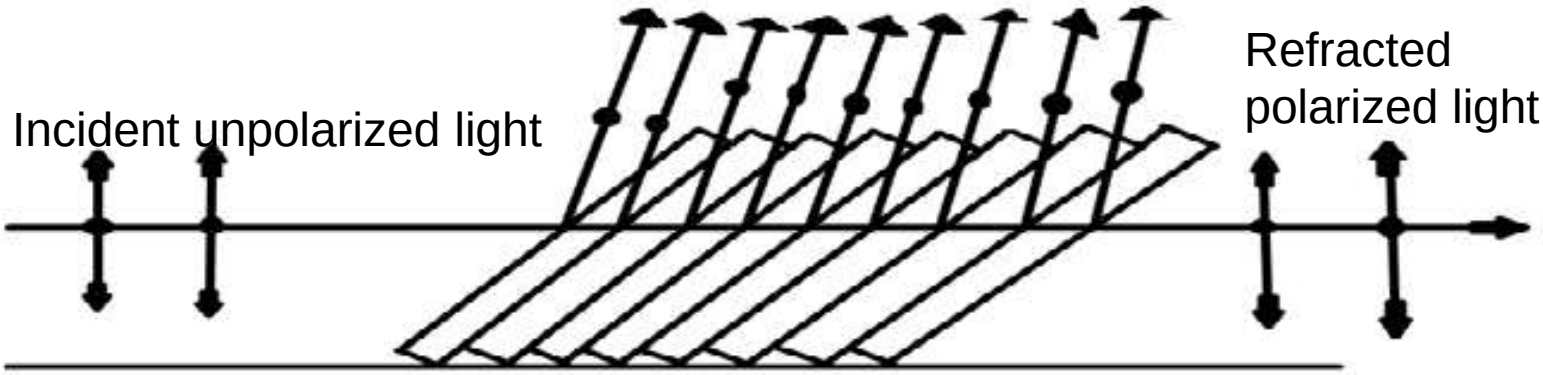






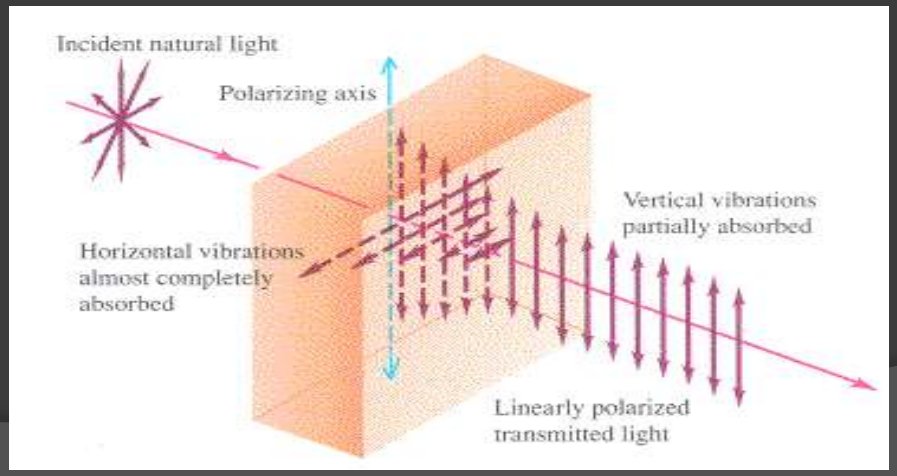
2) PPL BY REFRACTION

If a ordinary light is allowed to fall on a pile of plate on the polarizing angle then the reflected part becomes completely polarized and the transmitted part is partially polarized and this transmitted part again reflected& transmitted. As this after passing through 15 to 20 plates the refracted light becomes almost ppl.



3) BY SELECTIVE ABSORPTION (DICHROISM)

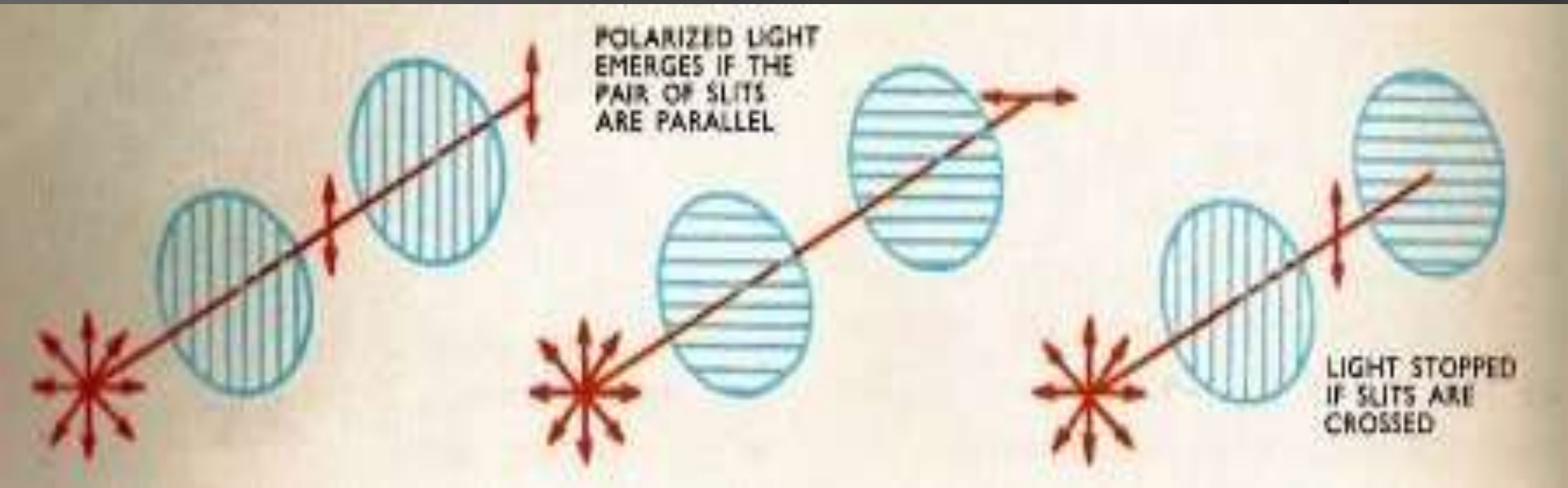
- When an unpolarized light is incident on a dichroic crystal(tourmaline) then it splits into two ppls . light wave which have its vibration perpendicular to the tourmaline's optic axis is almost completely absorbed and on the other hand if vibrations are parallel to optic axis then they will partially absorbed
- This phenomenon of selective absorption is used in the 'polaroids' (a commercial polarizing device).



POLAROID

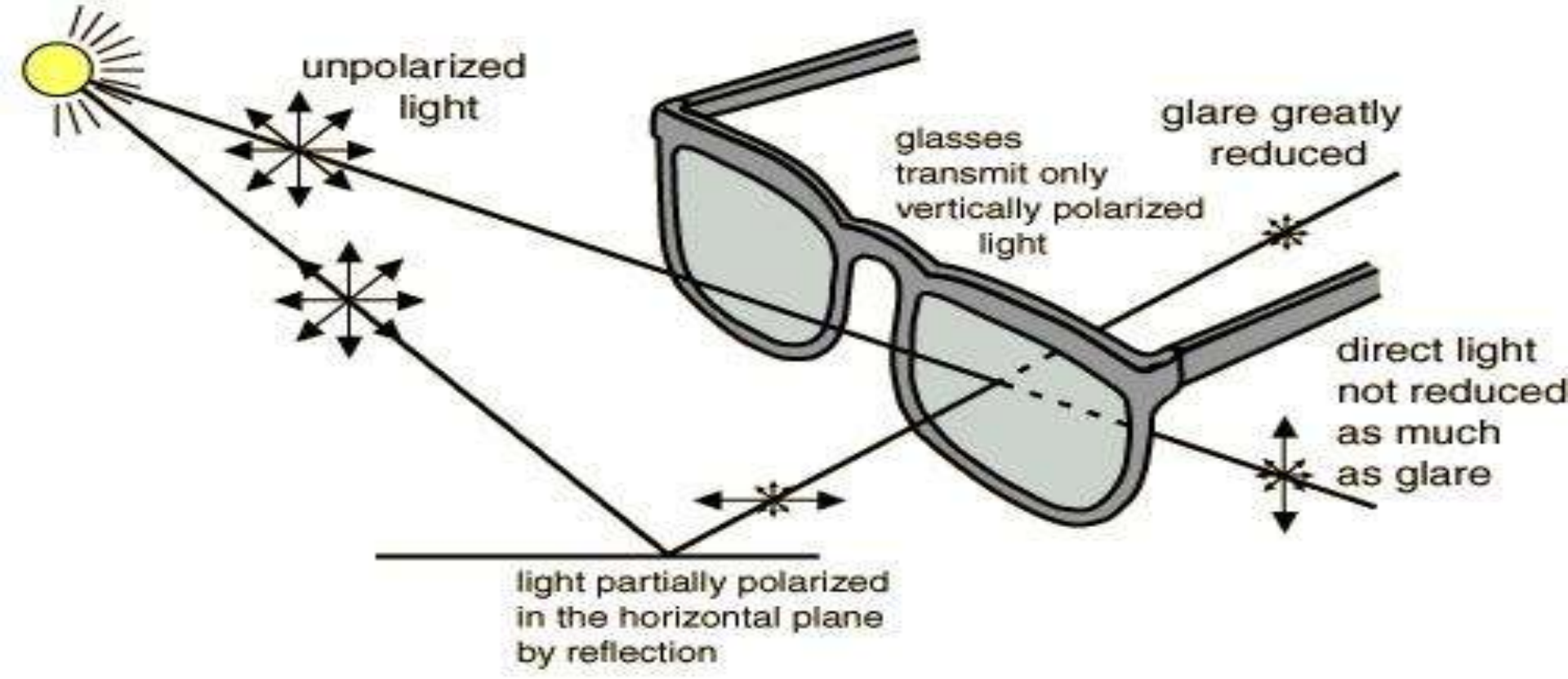
PRINCIPLE :-it is an optical device based on the principle of ‘selective absorption’ to produce ppl for commercial purpose.

WORKING :-when unpolarized light beam is allowed to pass through a polaroid(polarizer),it splits into two ppl beams . light which has its vibrations perpendicular to polaroid’s optic axis is completely absorbed.For detection of ppl we use another polaroid(analyzer).If both are in parallel position then intensity of transmitted light is max.otherwise (crossed position) intensity will be 0(min).



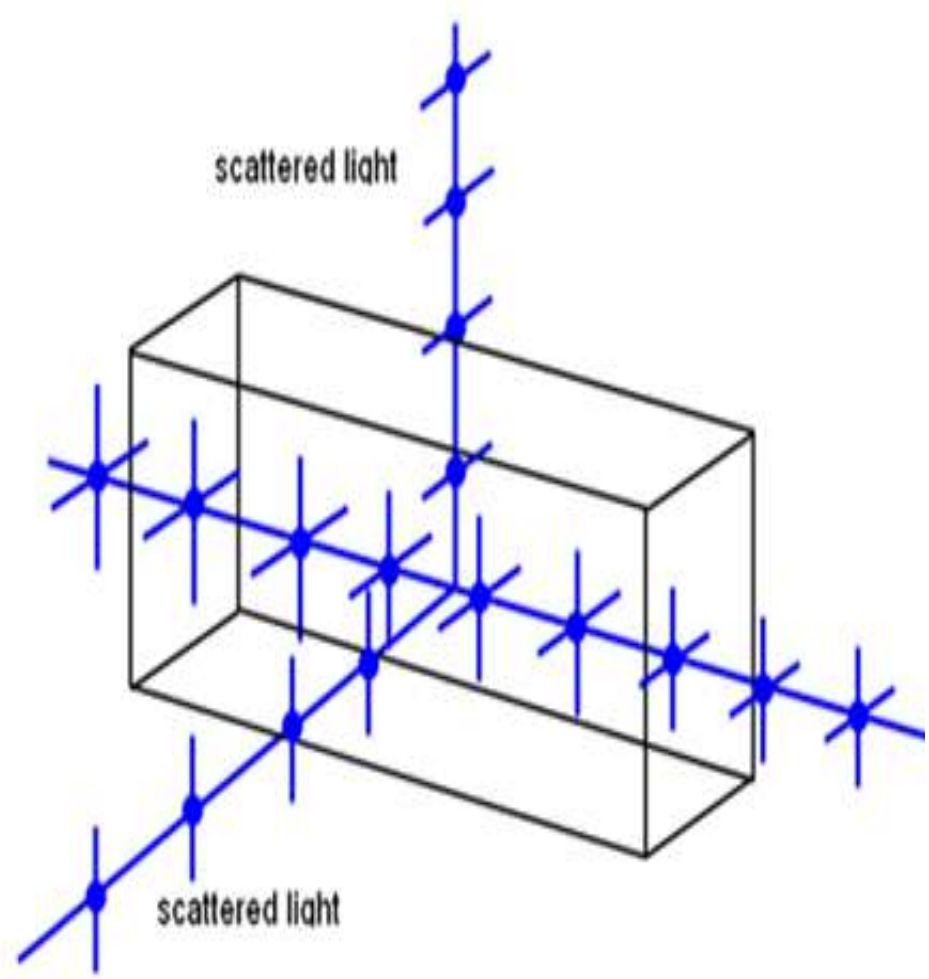
USE OF POLAROID IN SUNGLASSES

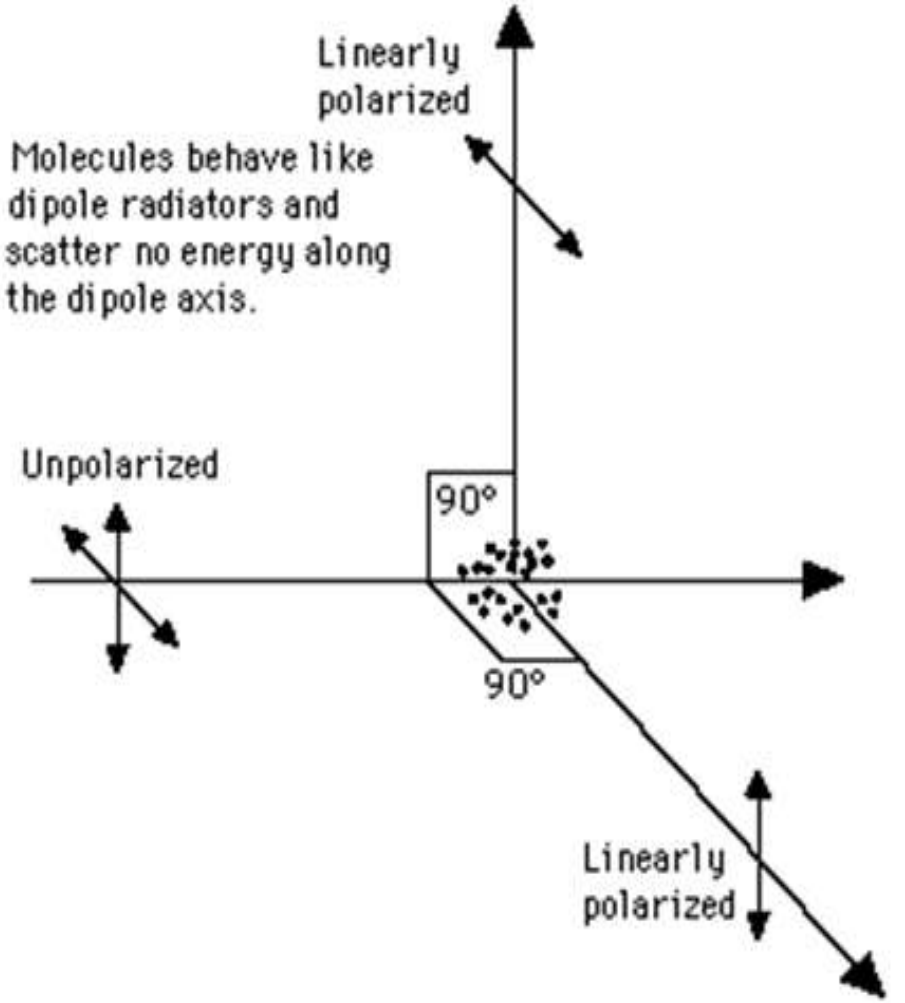
Polaroid are used in sun-glasses to cut off the glare of light reflected from horizontal surfaces.



4) BY SCATTERING

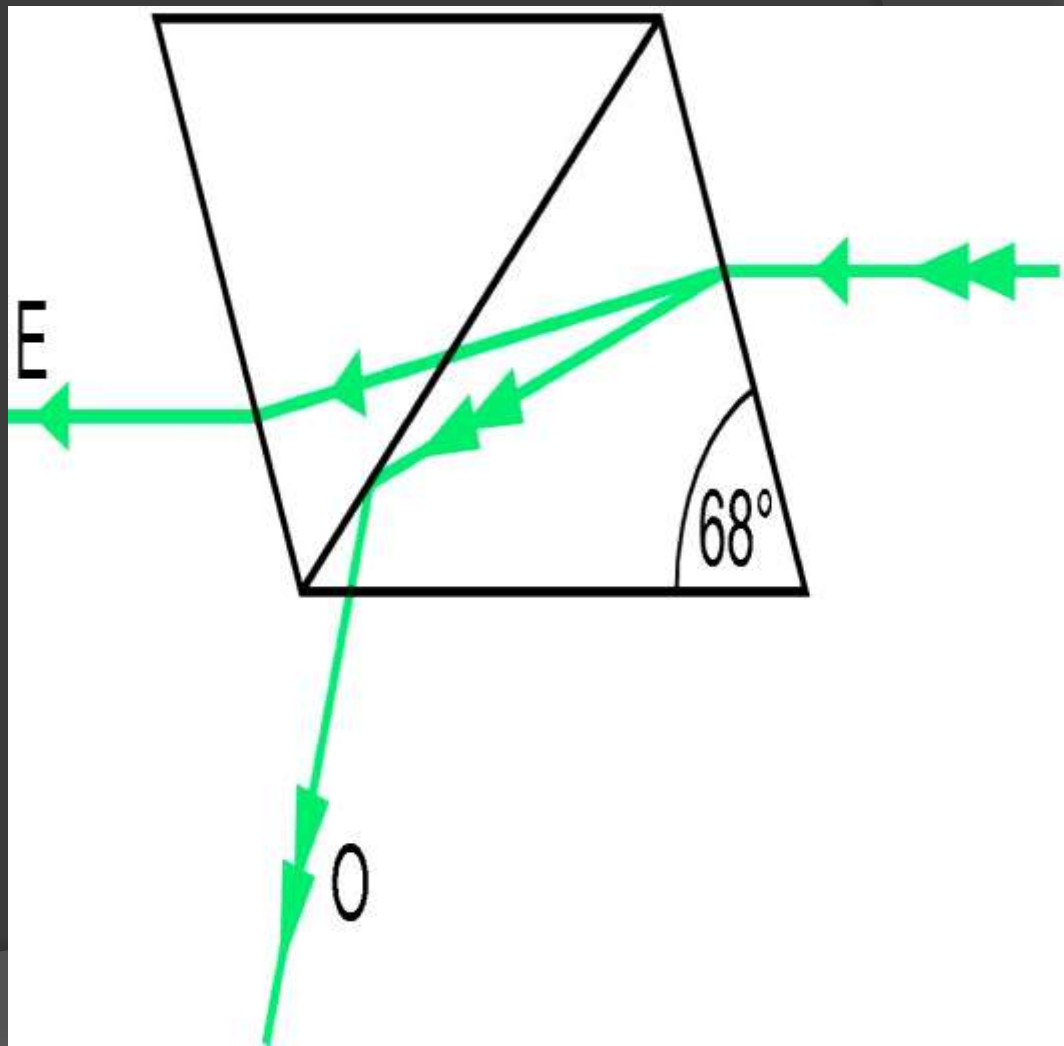
The scattering of light off air molecules produces ppl in the plane perpendicular to the incident light





5) BY DOUBLE REFRACTION (BIREFRINGEMENT)

- When ordinary light is allowed to pass through a calcite or quartz,it splits into two refracted beams(O-ray&E-ray)and both ara ppl.



‘O-RAY’

1)It’s vibrations are perpendicular to the calcite’s optic axis.

2)Vibrations are in the plane of light incident

3) It obey the snell’s law.

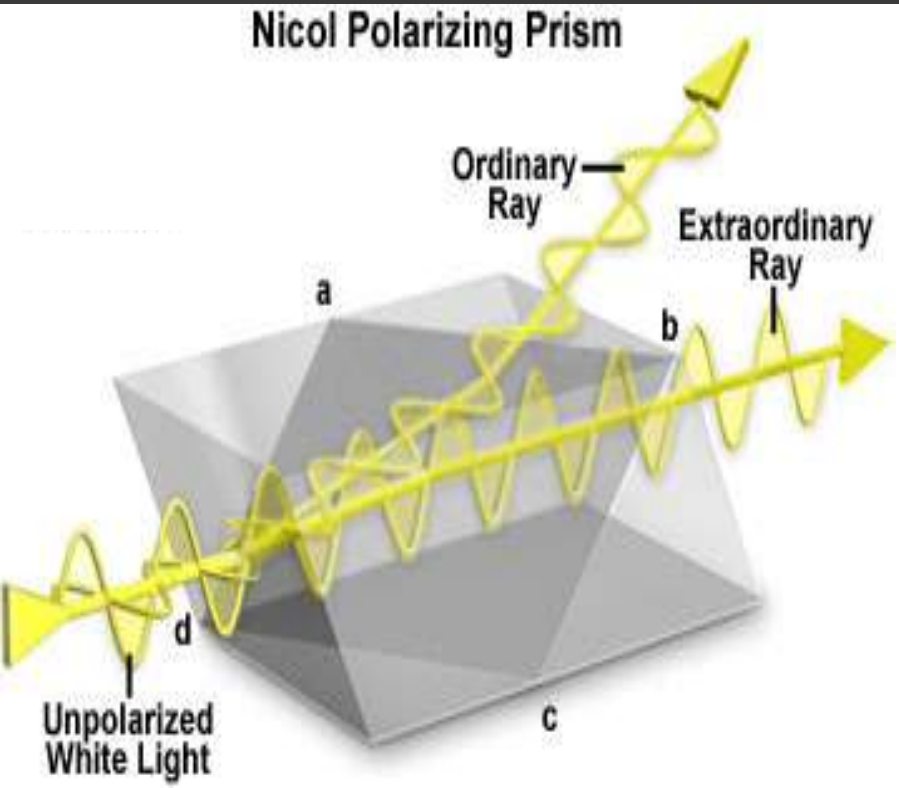
4) It travels in the crystal with the same speed in all the directions.

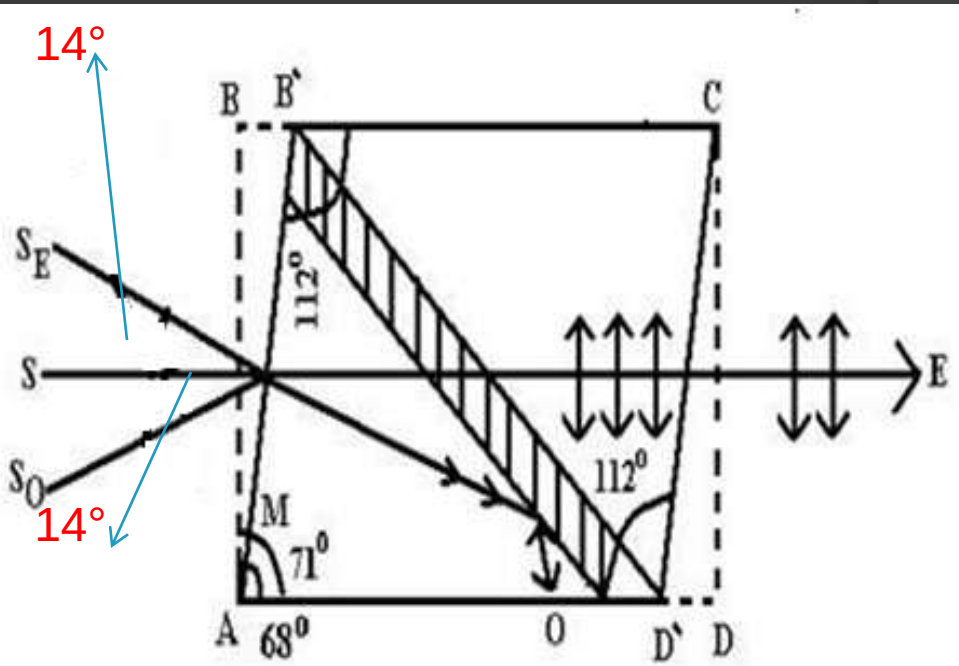
‘E-RAY’

1) It’s vibration are parallel to the calcite’s optic axis.
2) Vibrations are perpendicular to the plane of light incident
3) It don’t obey the snell’s law.
4) It travels in the crystal with a speed that varies with direction.

NICOL PRIZM

- PRINCIPLE :-It is based on the phenomenon of double refraction made from calcite to get ppl.
- WORKING :-when an unpolarized light is allowed to fall on nicol prism then due to double refraction it splits into two ppls(O-ray & E-ray) .the Nicol Prism is designed in such a way that the O-ray is eliminated by TIR . Hence only E-ray , ppl is transmitted through the prism.





ACTION OF NICOL PRISM

- The ref.indux of calcite for O-ray is(μ□ =1.65) is greater then E-ray(μ□ =1.48).The ref.indux of canada balsam(μ□ □ =1.55) lies midway the ref.indices of calcite crystal for the O-ray & E-ray.
- O-ray going from denser to rarer med□,will suffer TIR and the E-ray going from rarer to denser med□,will eliminate through crystal thus we get ppl.

The refractive index of ordinary ray with respect to Canada Balsam,

$$= \frac{\mu_0}{\mu} = \frac{1.66}{1.55}$$

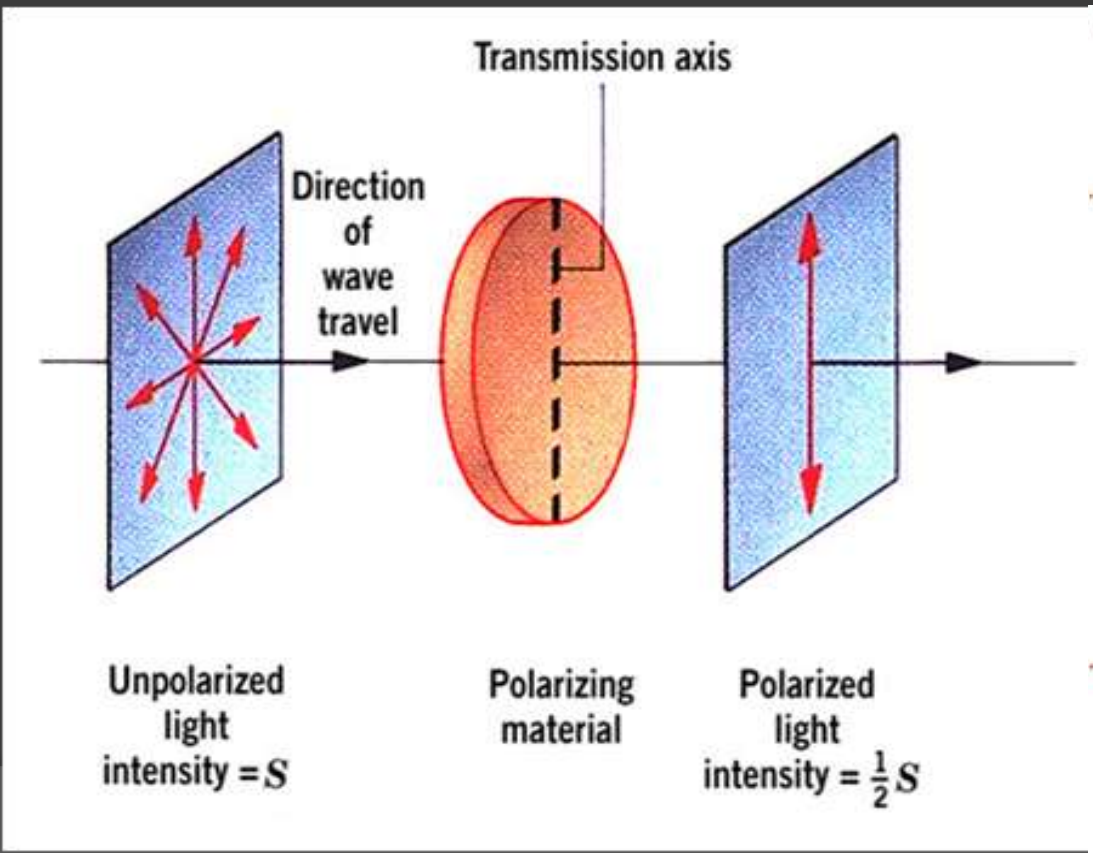
$\therefore$ If θ is critical angle, we have

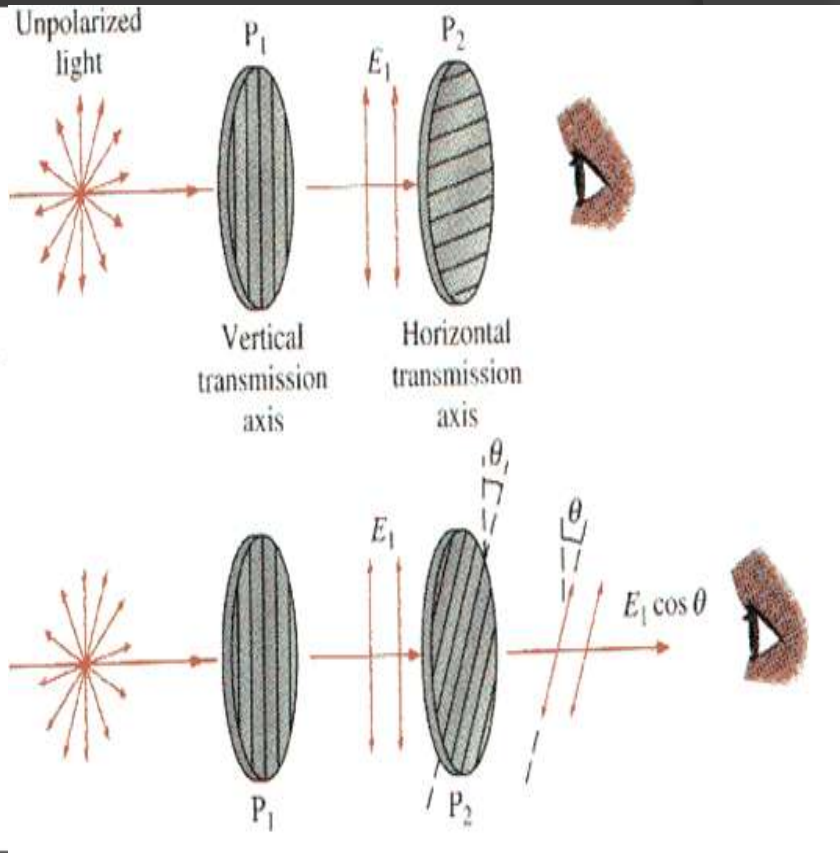
$$\sin\theta = \frac{1.66}{1.55} = 0.933$$

$$\theta = \sin^{-1}(0.933) = 69^{o}$$

MALUS's LAW

- Malus states that "The intensity of polarized light transmitted through the analyzer is proportional to the square of cosine of the angle($Cos^2\theta$) b/w the plane of transmission of the polarizer and the analyzer".{$I=I_0 Cos^2\theta$} (I_0 =intensityof original light)}





GENERAL EQUATION OF AN ELLIPSE

$$x^2/a^2 + y^2/b^2 - 2(xy/ab)\cos\delta = \sin^2\delta$$

Where,

- a=Acosθ(amplitude of E-ray)
- b=Asinθ(amplitude of O-ray)
- A=amplitude of incident ppl on crystal
- δ=phase difference b/w O-ray&E-ray
- θ=angle b/w incident ppl & optic axis

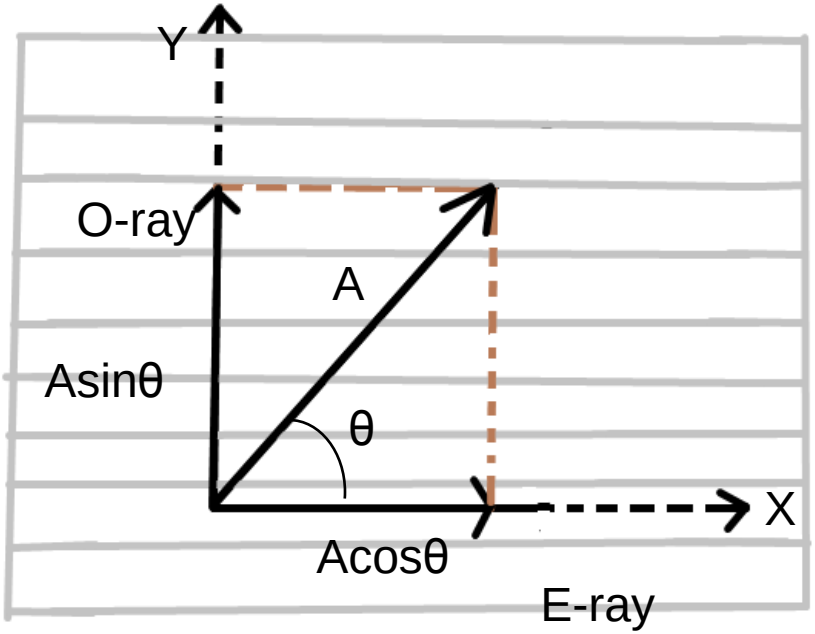
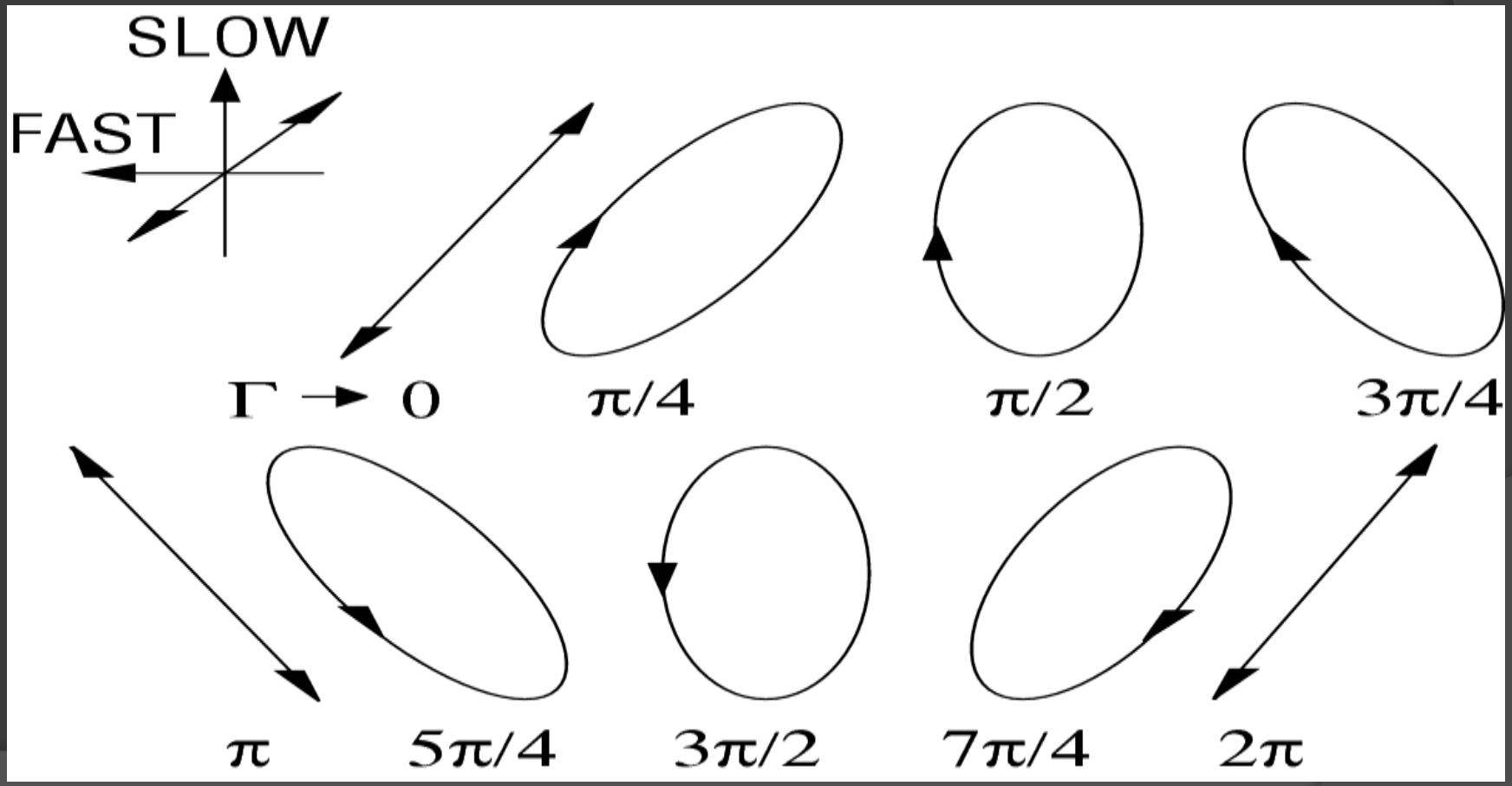


Fig:Components of Amplitudes

SPECIAL CASES OF THE GENERAL EQUATION OF ELLIPSE

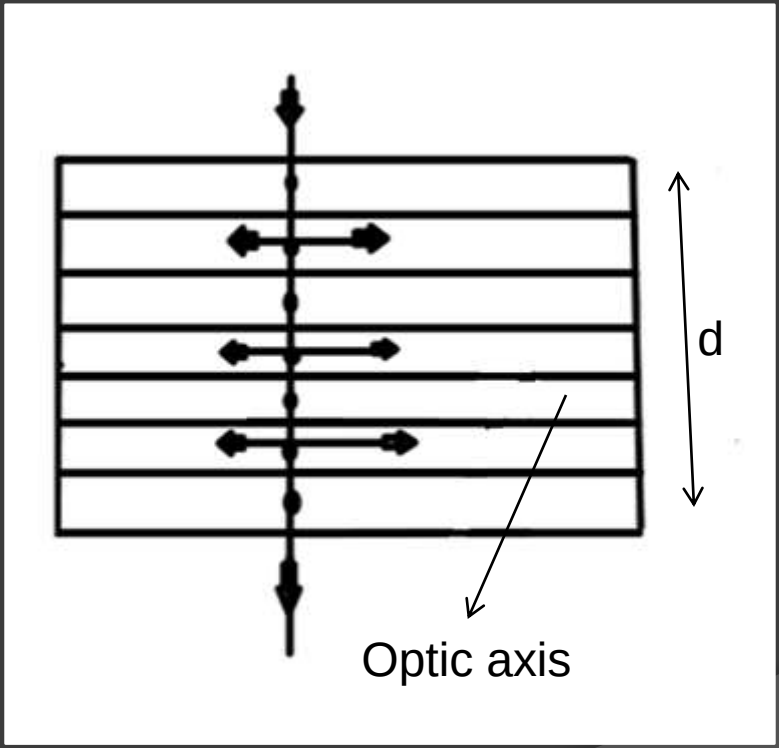


PHASE RETARDATION PLATE

A doubly-refracting crystal plate of uniform thickness whose refracting surfaces are parallel to its optic axis and produces a definite phase difference b/w O-ray & E-ray , is called ‘PRP’.

‘TYPES’

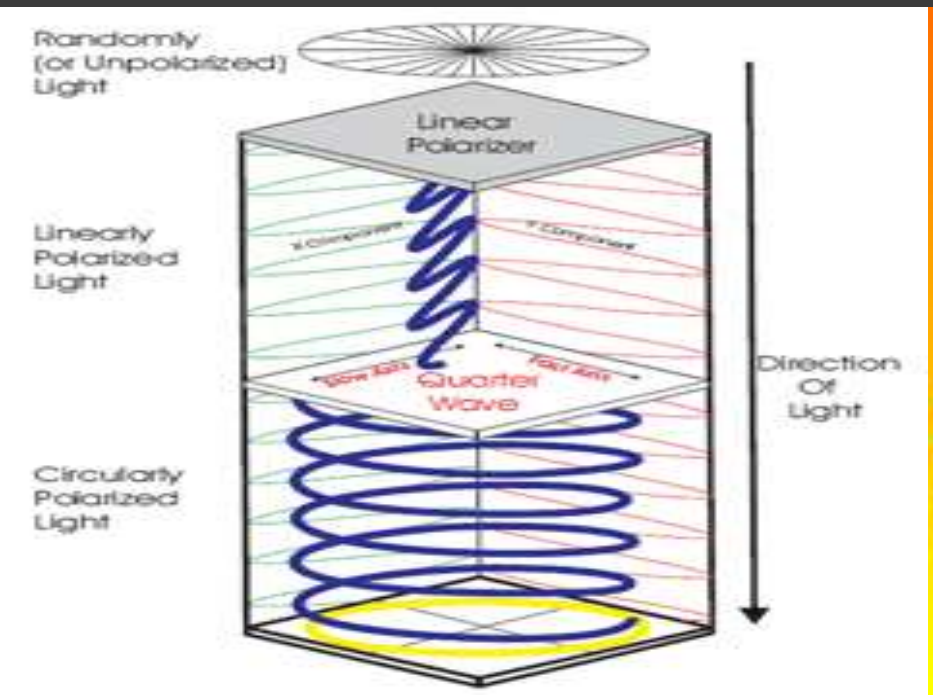
1) QWP
2) HWP

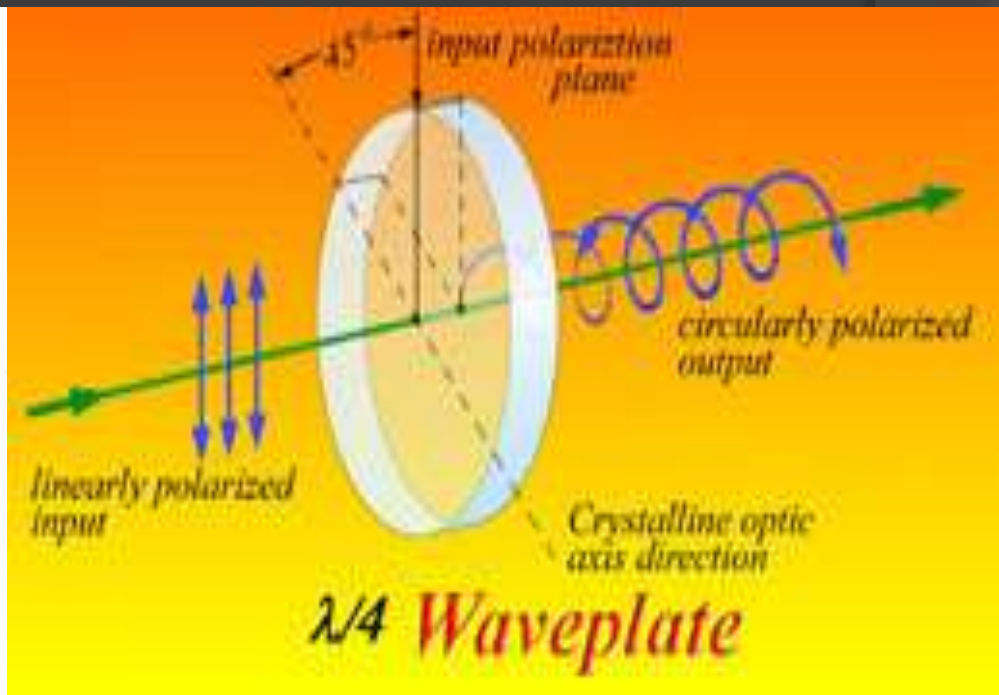


QWP (λ/4 PLATE)

- The QWP is capable of producing a path difference(Δx)of λ/4 or a phase difference(ΔΦ) of ´/2 b/w the O-ray & E-ray, when a polarised light of wavelength ‘λ’is normally incident on it.
- The thickness of QWP(d)=λ(4n+1)/4(μ□-μ□)

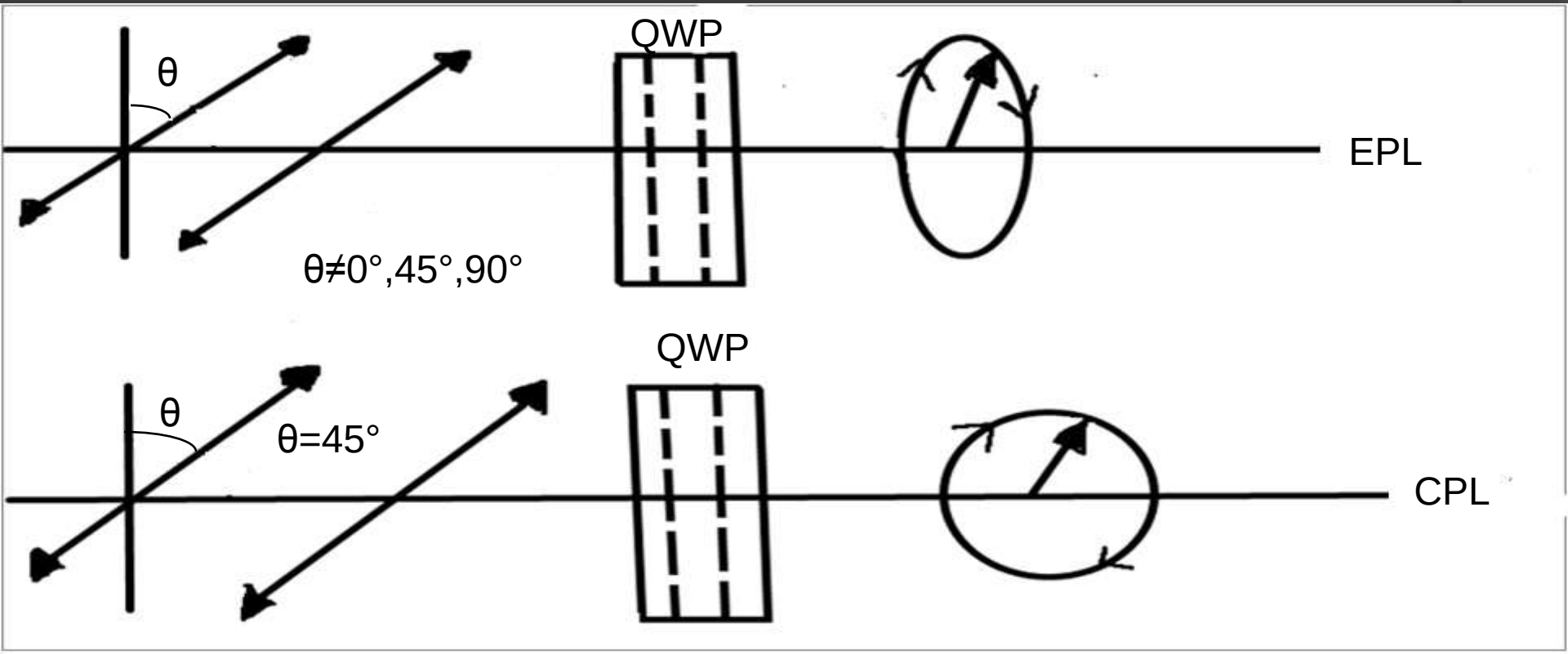
  { where n=0,1,2,3……}.
- The QWP is used for the production of CPL & EPL.





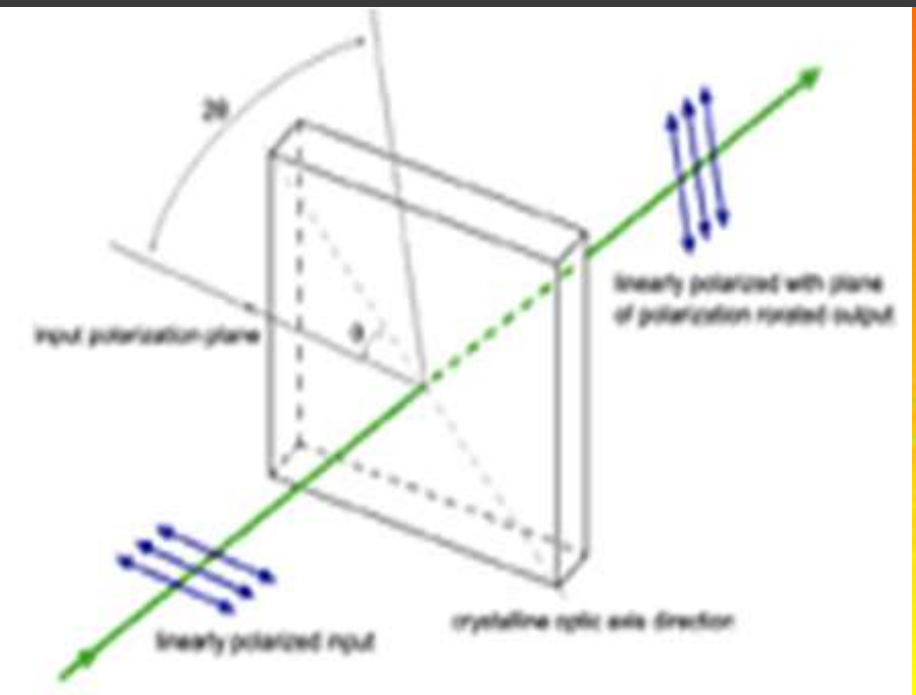
WORKING OF ‘QWP’

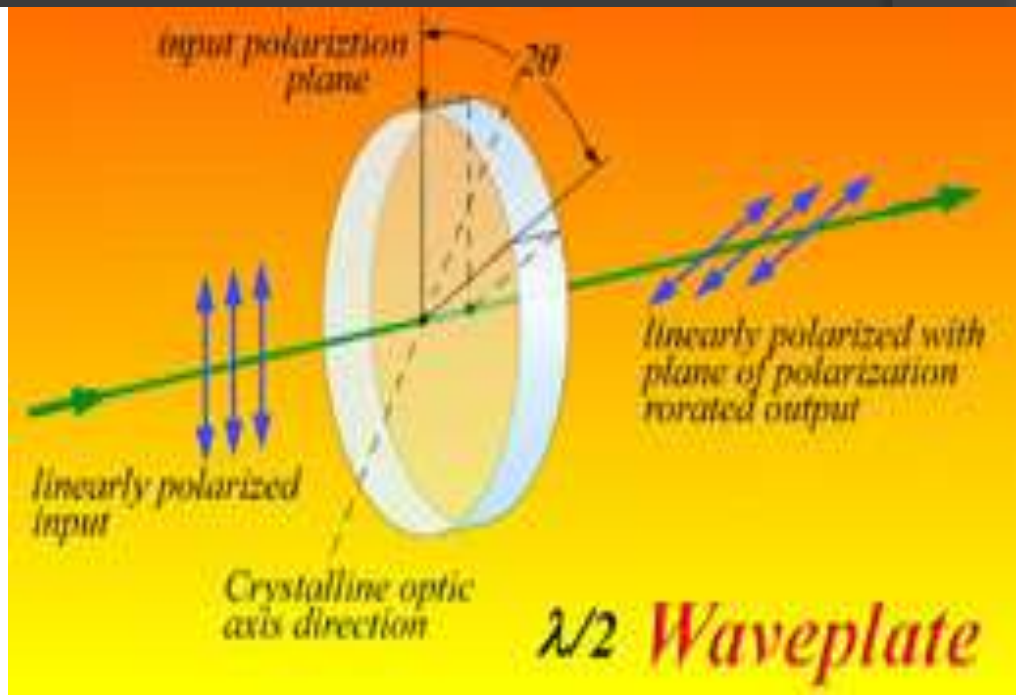
- If the vibration of ppl makes an angle(Ɵ)45□ with the optic axis of QWP then the emergent light is CPL.
- Otherwise(Ɵ≠0□ ,45□ ,90□) the emergent light is EPL.



HWP (λ/2 PLATE)

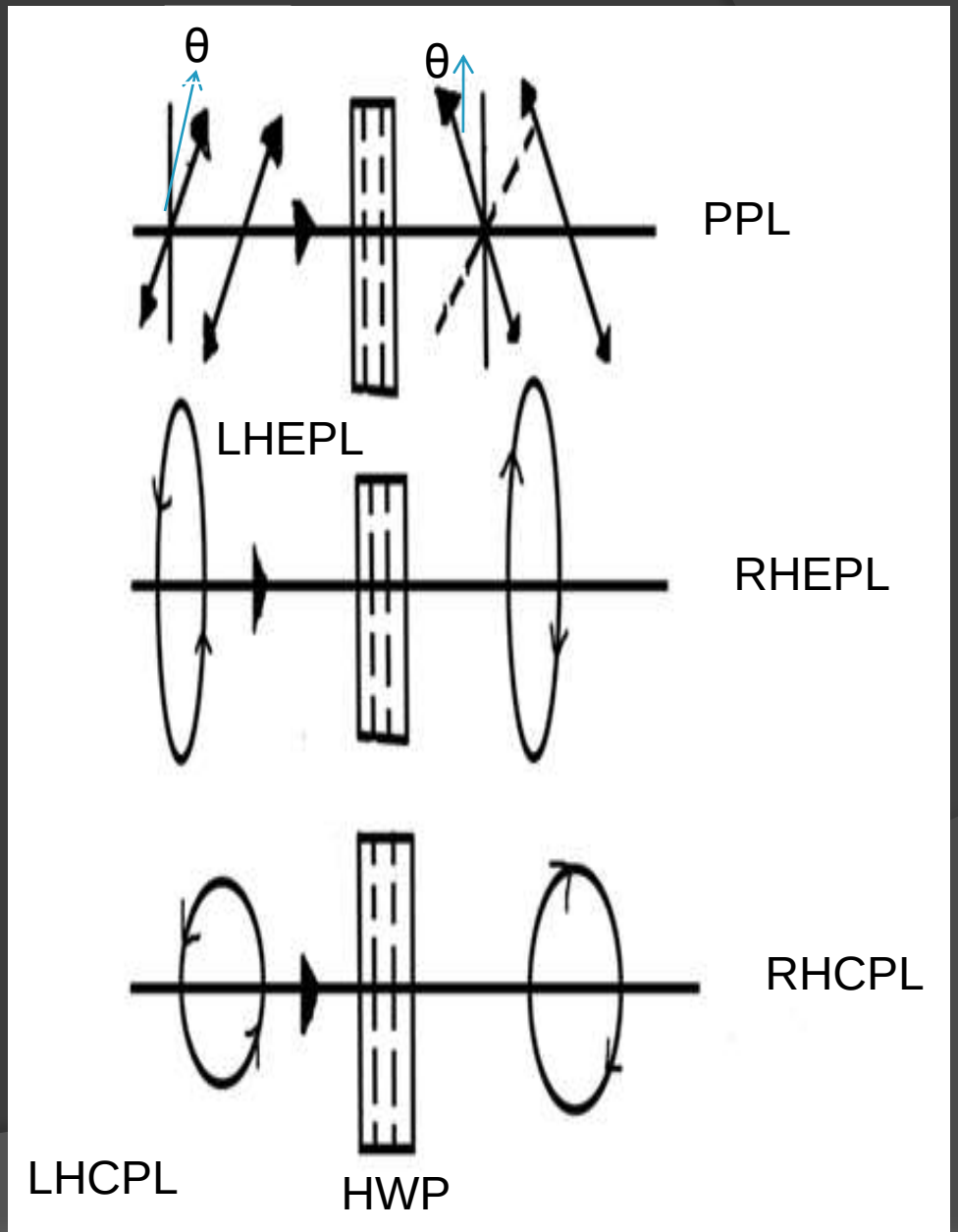
- The HWP is capable of producing a path difference(Δx)of λ/2 or a phase difference(ΔΦ) of´ b/w the O-ray& E-ray , when a polarised light of wavelength ‘λ’ is normally incident on it.
- The thickness of HWP(d)=λ(2n+1)/2(μ□-μ□) {where n=0,1,2,3…..}.
- The HWP is used for changing the direction of vibration of polarized light.



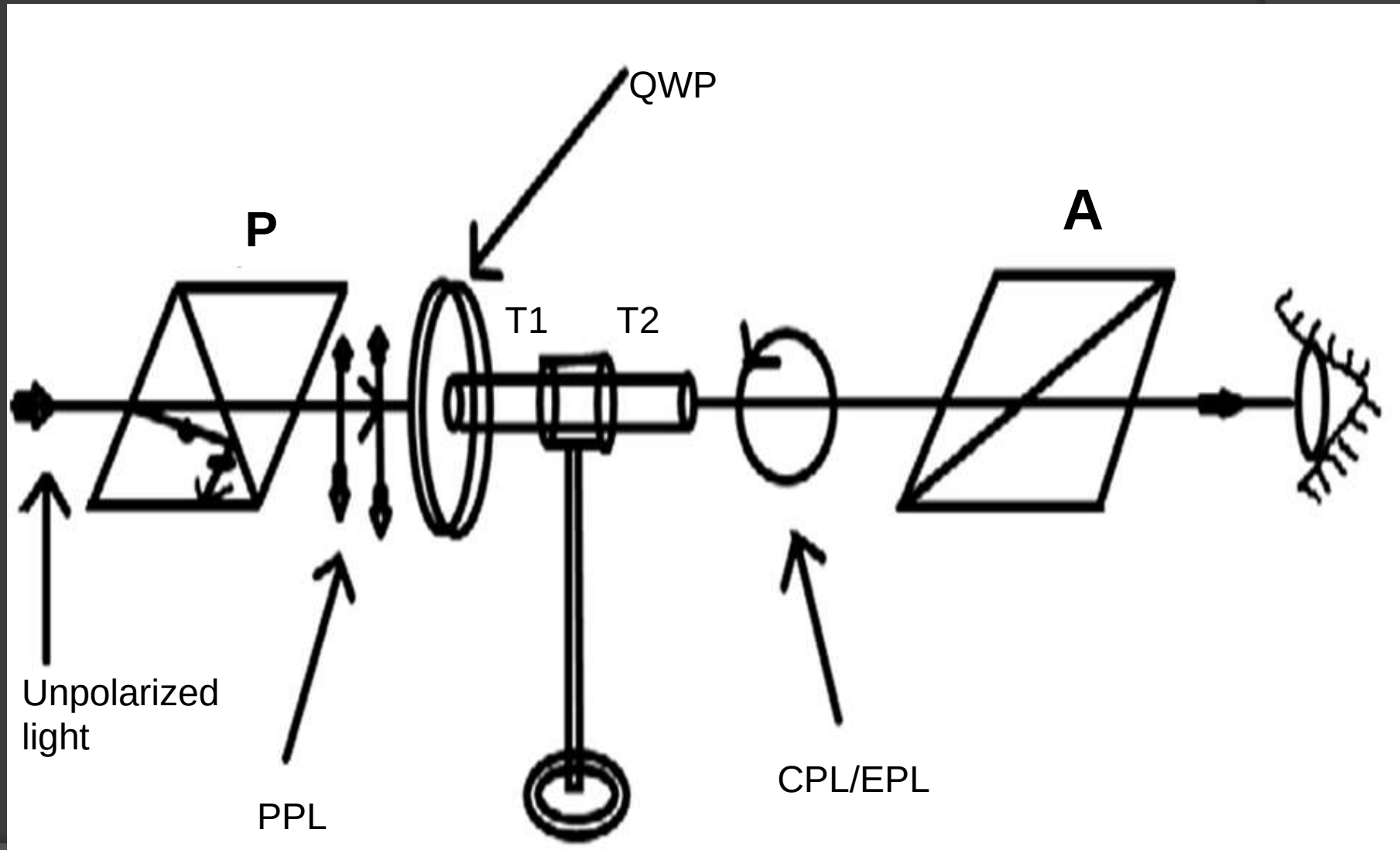


WORKING OF ‘HWP’

- When a ppl beam incident normally on the HWP emerges as a ppl beam but rotated such that its angle to the optic axis is twice that of the incident beam.
- HWP can also change left-handed EPL (ACW)or CPL into respective right-handed(CW) EPL or CPL.

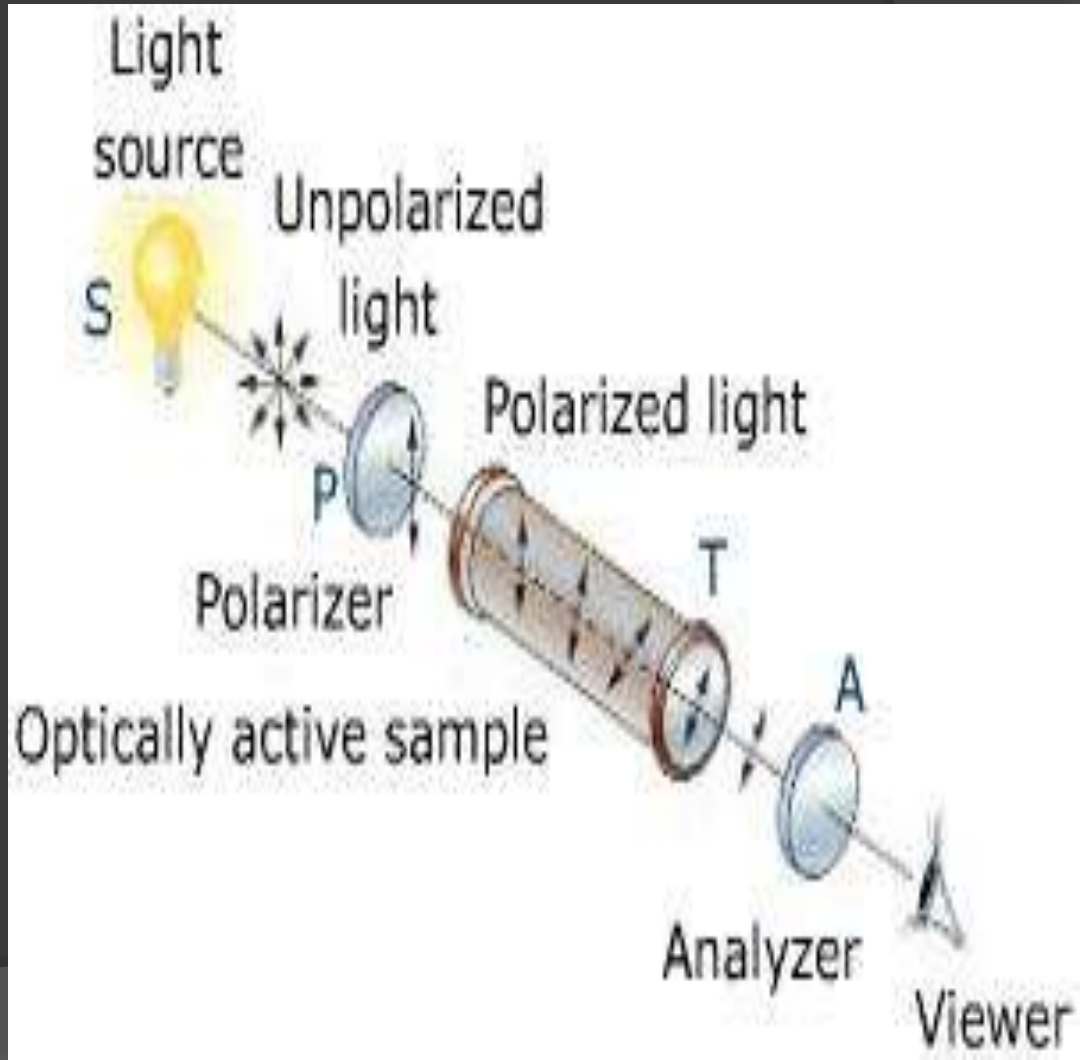


PRODUCTION OF EPL,CPL BY ‘QWP’



OPTICAL ACTIVITY

- The phenomenon of ‘Rotation of plane of polarization of the ppl about its direction of propagation’ is called ‘Optical Activity’ or ‘Rotatory Polarization’.

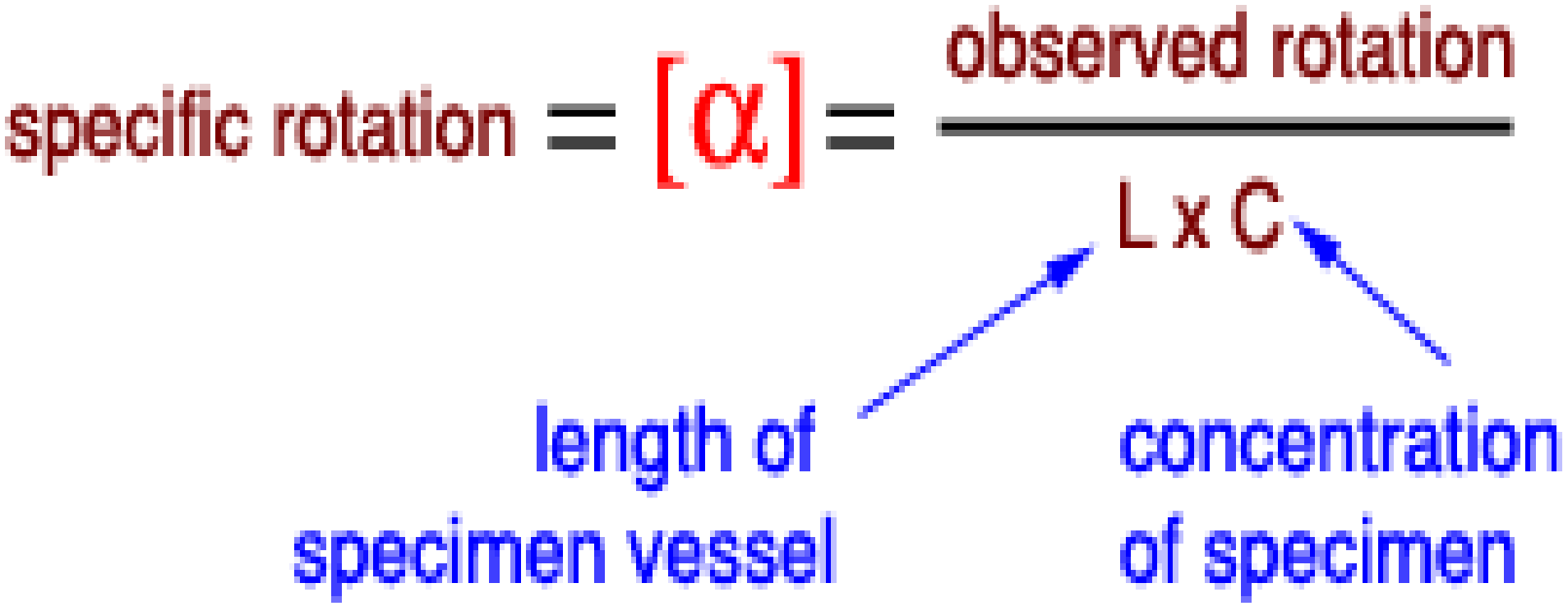


LAWS OF OPTICAL ROTATION

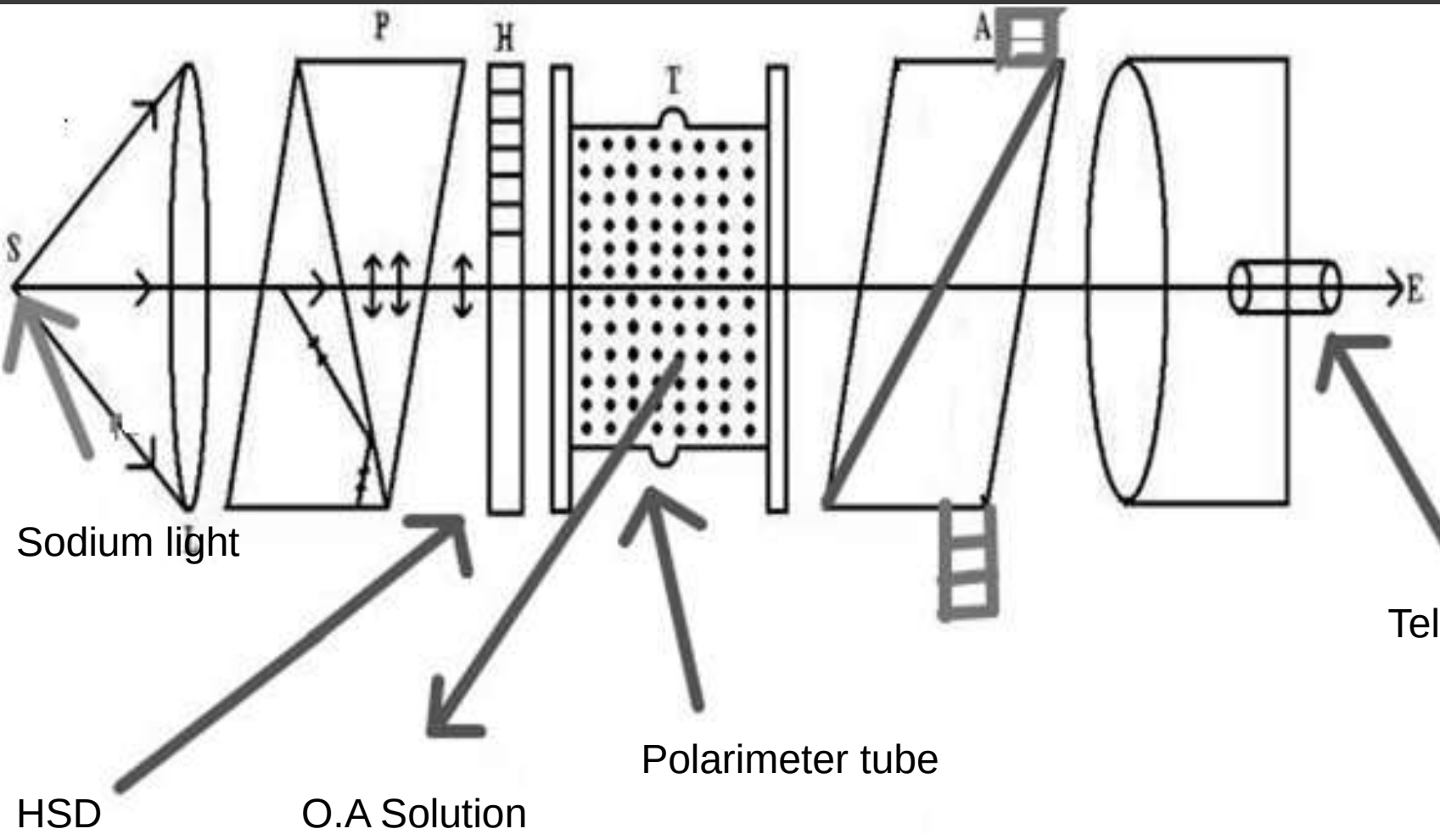
- θ(amount of rotation) α l(length of medium).
- θ α c(concentration of solution).
- θ α $1/\lambda^2$(λ=wavelength of incident light).
- Depend upon temperature.

SPECIFIC ROTATION

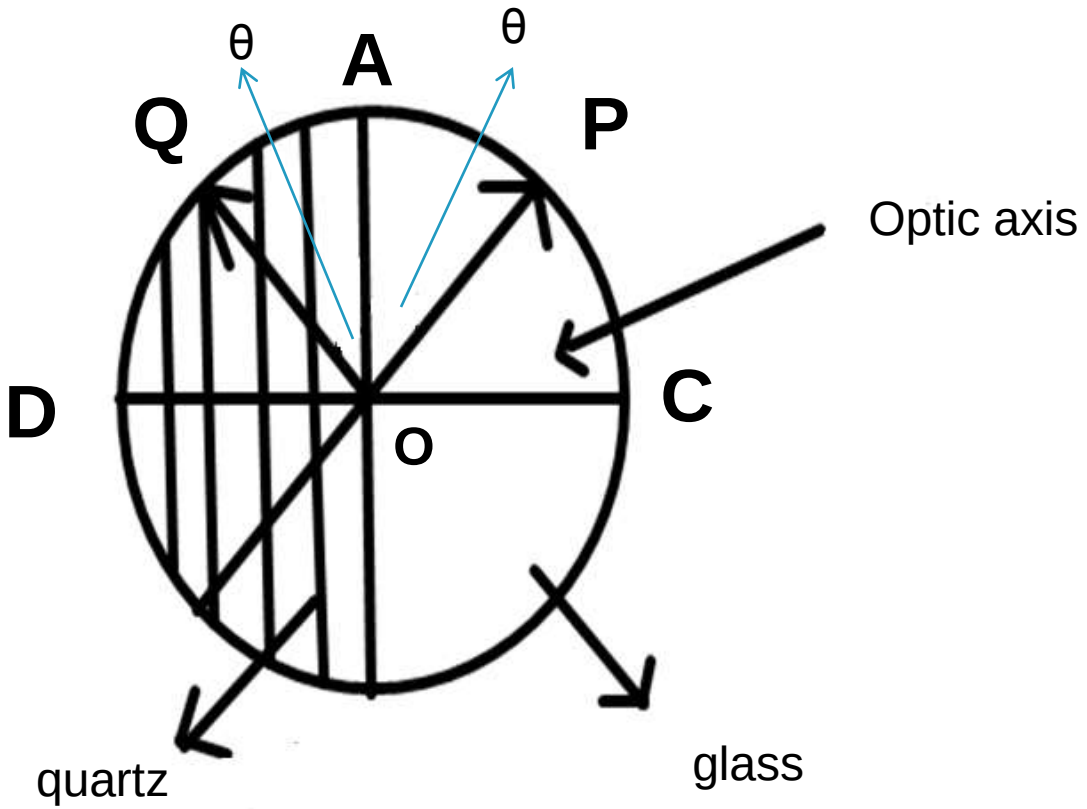
- Specific rotation (α)for a given temperature(t) and for a light of given wavelength(λ),is defined as the rotation (degree) produced by a decimeter (10cm) long column of an active substance of unit density(1 gm/cc).



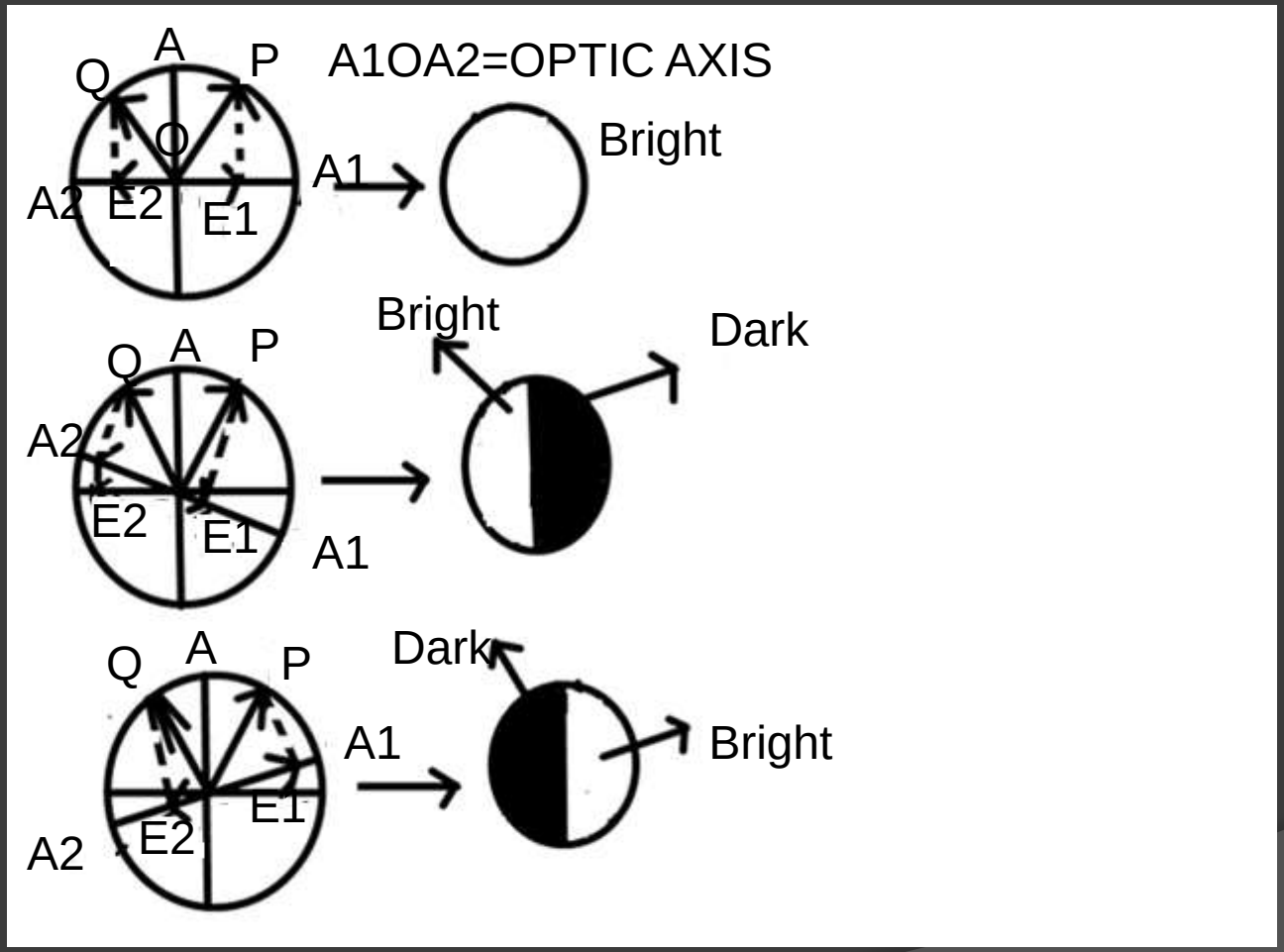
LAURENT'S HALF SHADE POLARIMETER (LHSP)



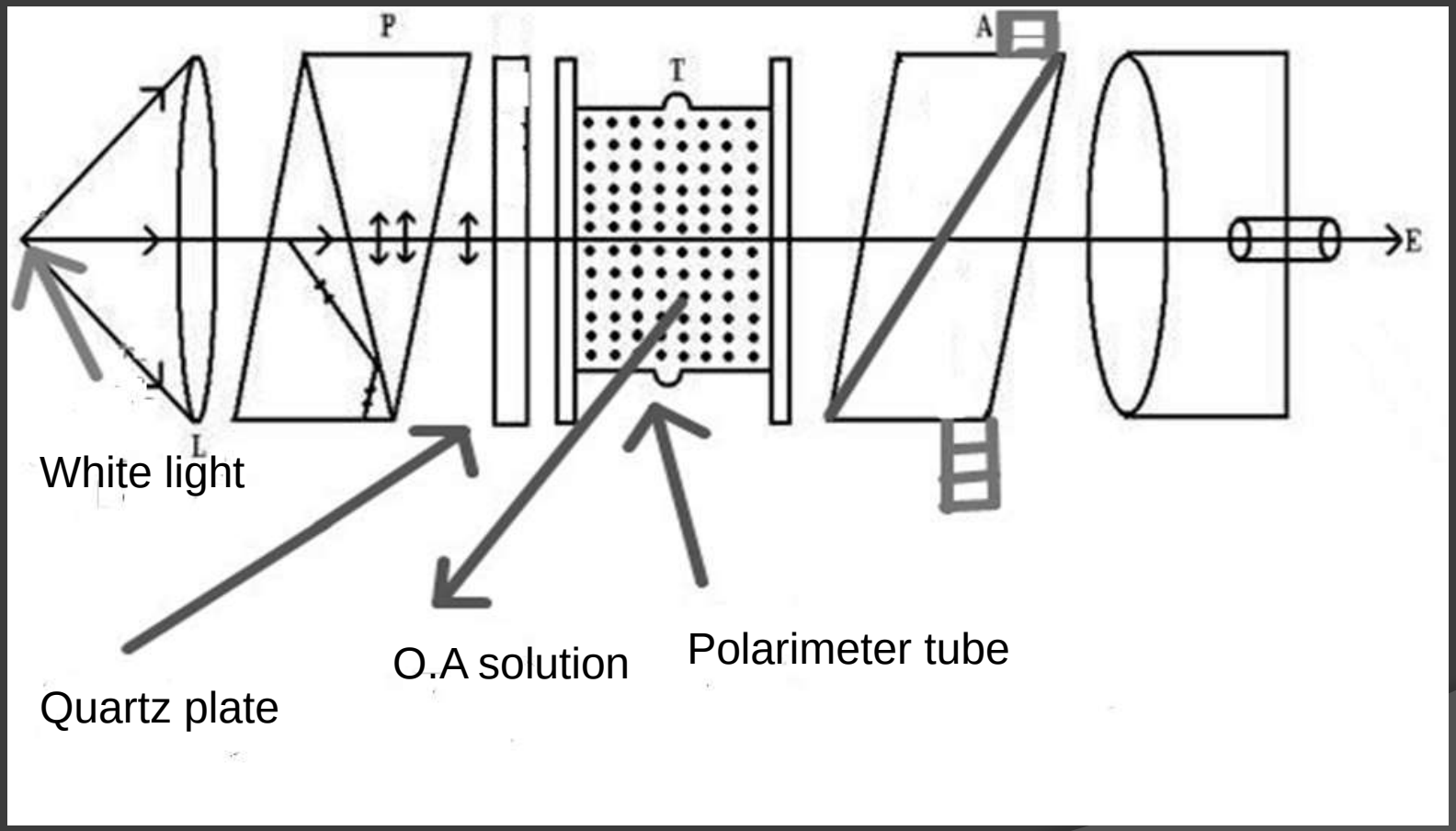
CONCEPT OF ‘HALF SHADE DEVICE’



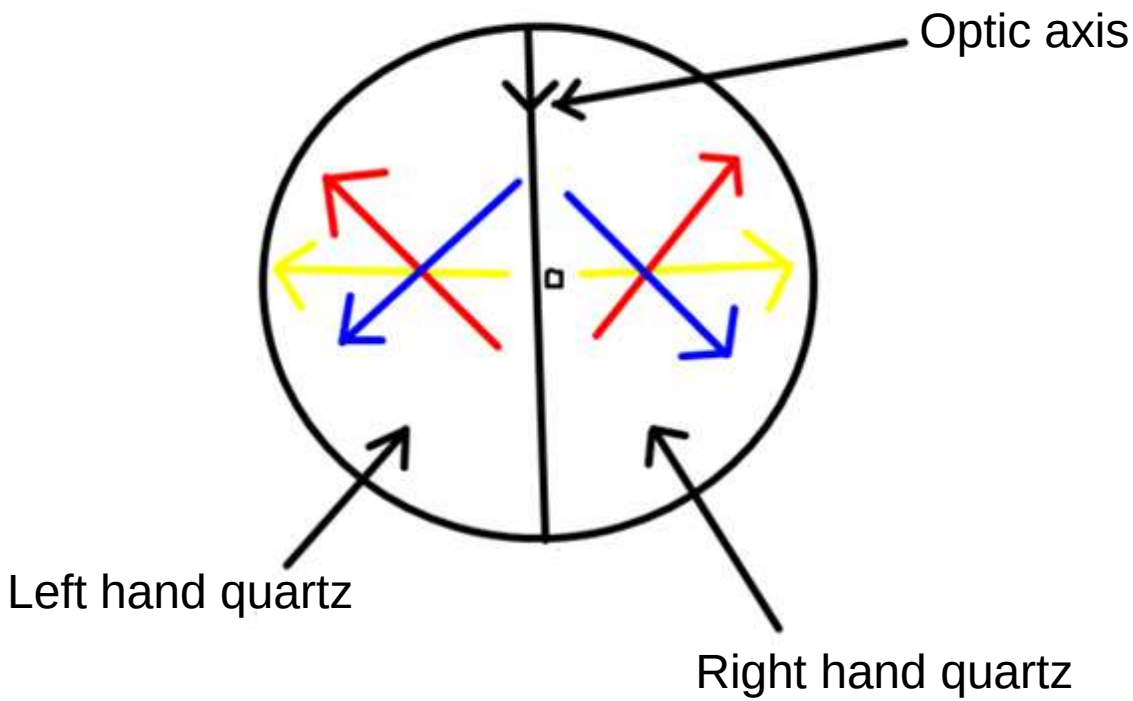
OBSERVAION ON FIELD OF VIEW DUE TO ‘LHSP’



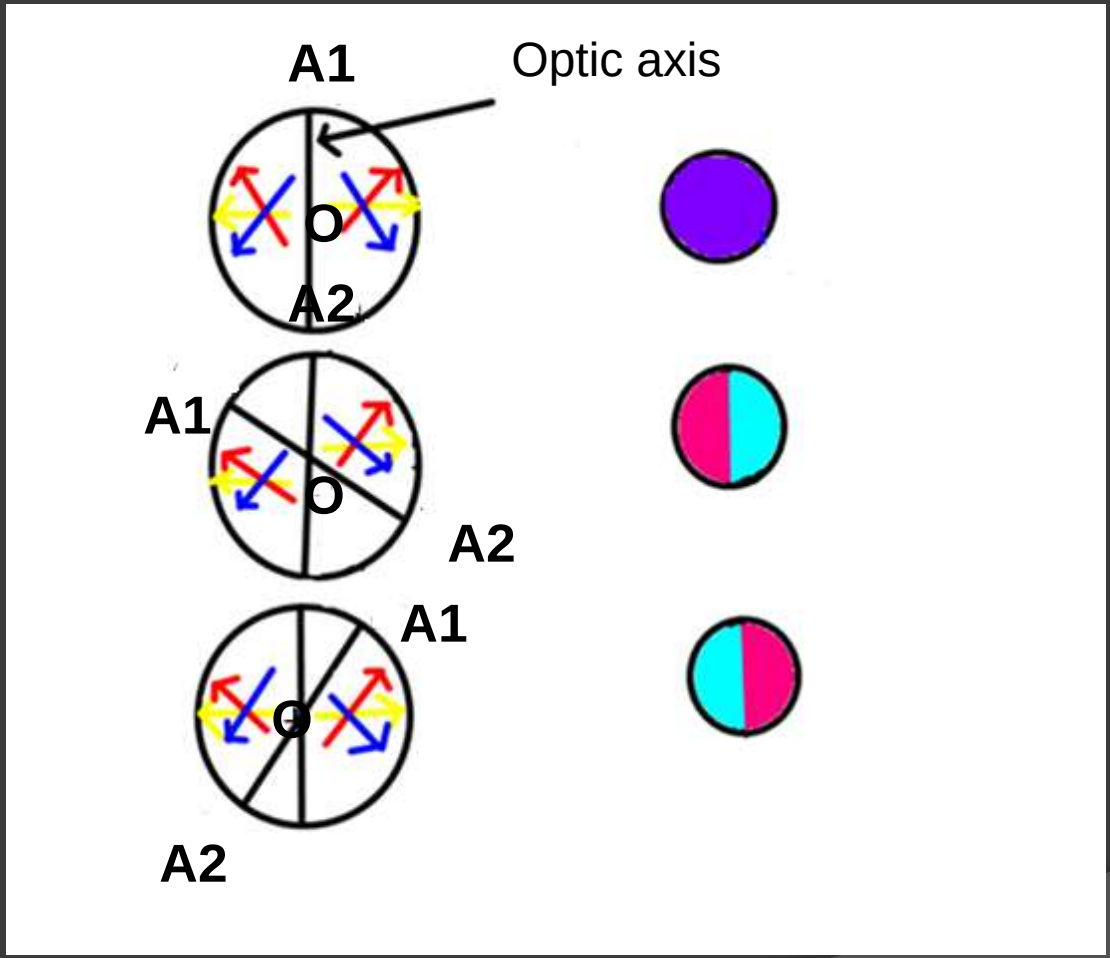
BIQUARTZ POLARIMETER (BP)



CONCEPT OF ‘BIQUARTZ PLATE’



OBSERVATION ON FIELD OF VIEW DUE TO ‘BP’



Thanks

Any queries….