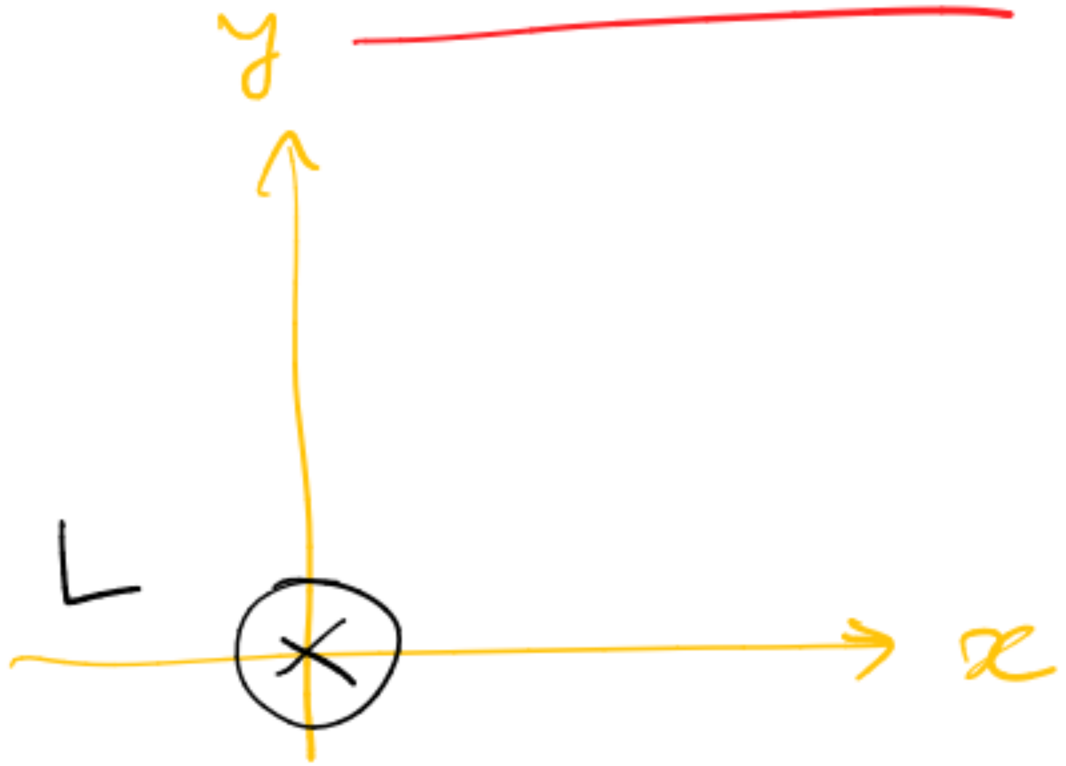
AS3520

Lecture 7



Consider a light wave whose electric field amplitudes along the x- & y- dims are

$$\begin{pmatrix} A_x e^{i\phi_x} \\ A_y e^{i\phi_y} \end{pmatrix} \nabla$$

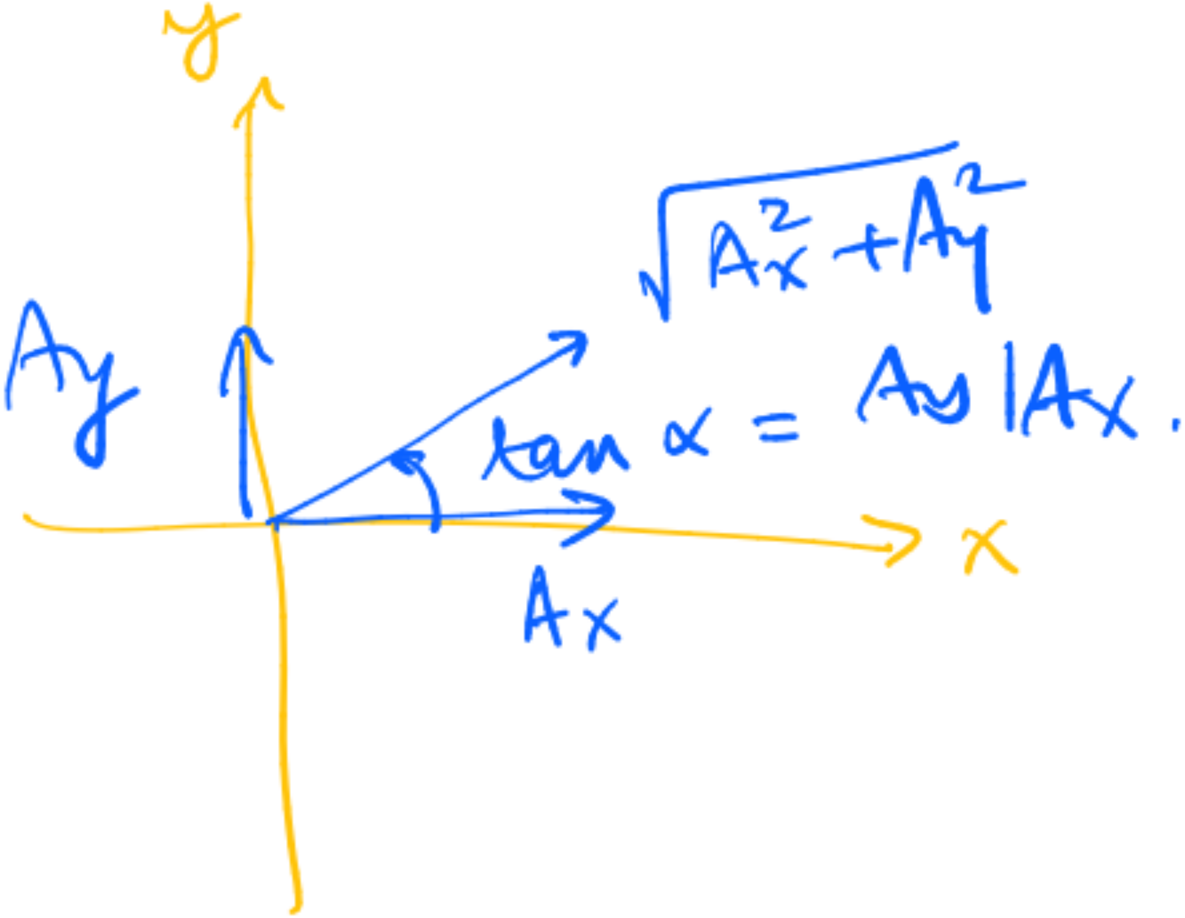
$$= \begin{pmatrix} A_x \\ A_y e^{+i\Delta} \end{pmatrix} e^{i\beta/2} e^{-i\Delta/2}.$$

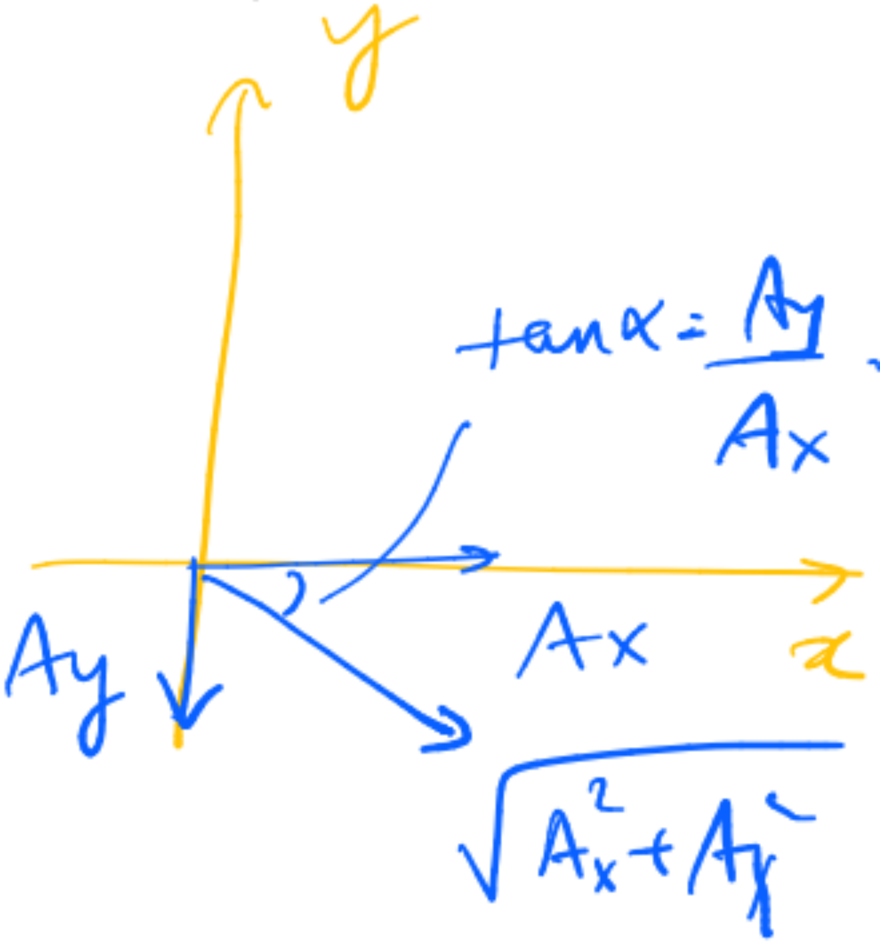
Plane polarised light:

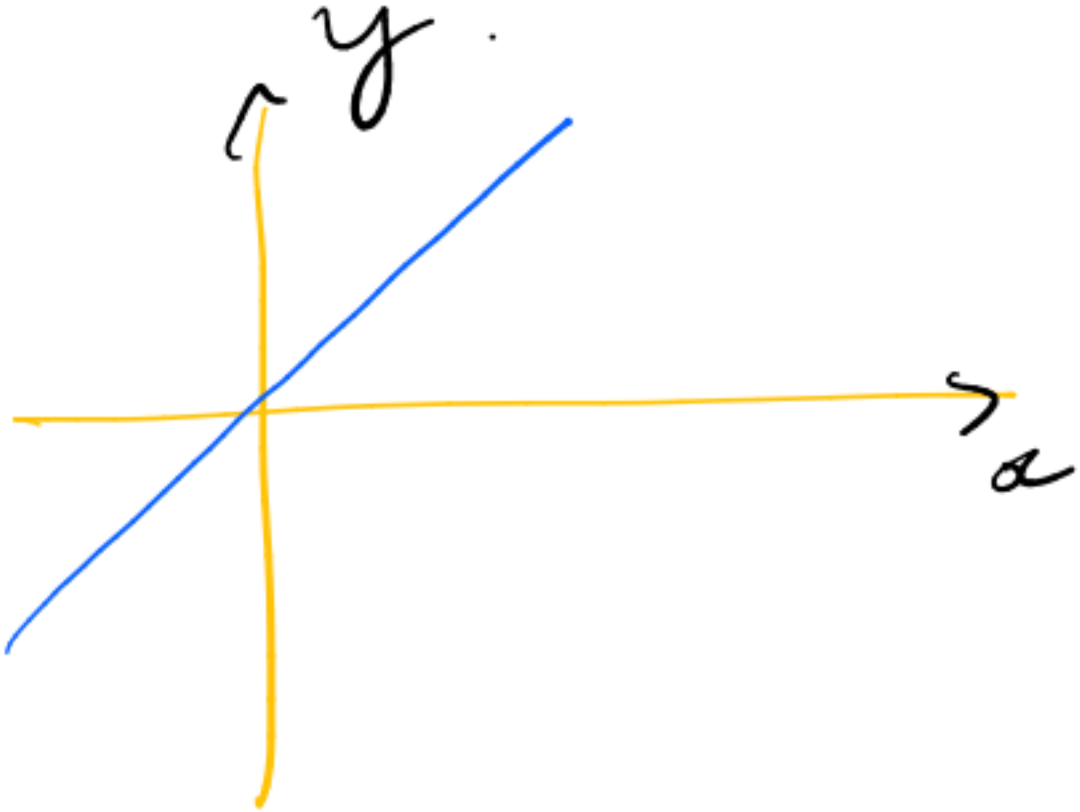
$$\Delta = 0 \quad \text{or} \quad \pi.$$

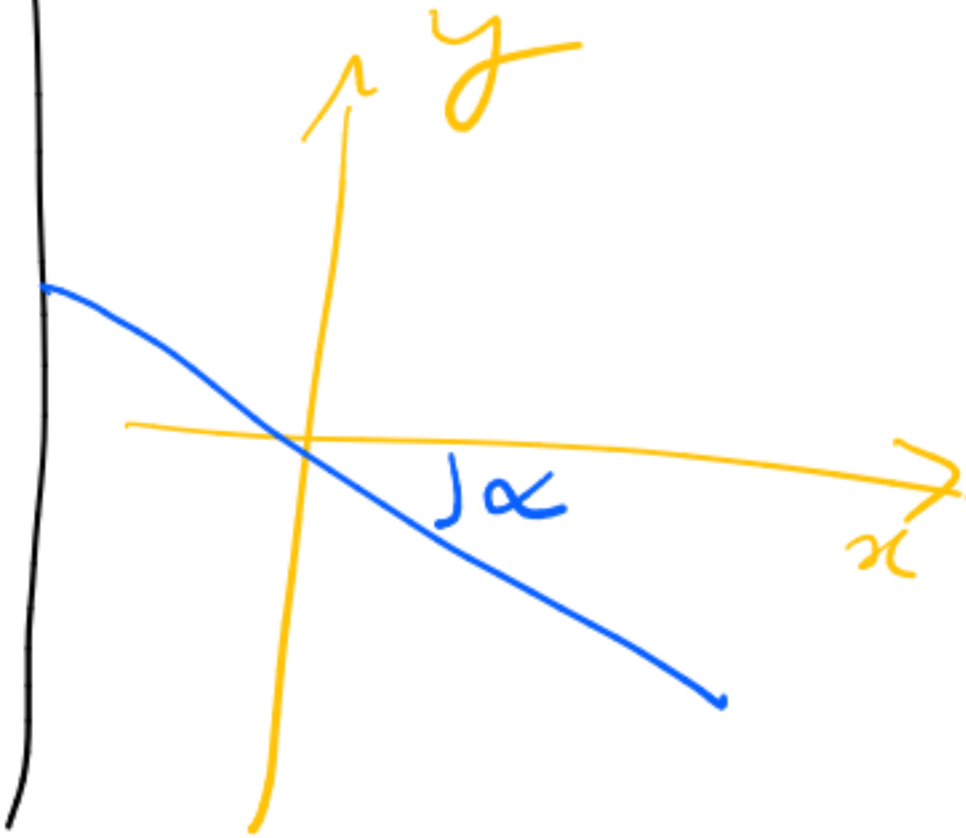
$$\swarrow \qquad\qquad\qquad \searrow$$

$$\begin{pmatrix} A_x \\ A_y \end{pmatrix} \qquad\qquad\qquad \begin{pmatrix} A_x \\ -A_y \end{pmatrix}$$









AmazonBasics Circular Polarizer Filter- 55 mm

Brand: AmazonBasics

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Circularly polarized light.

$$A_x = A_y$$

$$\Delta = \pm \pi/2$$

Light vector corresponding to circularly pol. light:

$$\begin{pmatrix} A_x \\ A_x e^{\pm i \frac{\pi}{2}} \end{pmatrix} = A_x \begin{pmatrix} 1 \\ \pm i \end{pmatrix}.$$

$$E_x = \mathrm{Re}\left[A_x \, e^{i\left(\frac{2\pi}{\lambda}(r-ct)\right)} \right]$$

$$E_x = A_x \cos\left(\frac{2\pi}{\lambda}(r-ct)\right).$$

$$E_y = \mathrm{Re}\left[\underset{\pm i A_x}{\underset{\uparrow}{A_y}} \, e^{i\left(\frac{2\pi}{\lambda}(r-ct)\right)} \right]$$

$$= \mathrm{Re}\left[A_x(\pm i)\left(\cos\left(\frac{2\pi}{\lambda}(r-ct)\right) + i \sin\left(\frac{2\pi}{\lambda}(r-ct)\right)\right) \right]$$

$$E_y = \mp A_x \sin\left(\frac{2\pi}{\lambda}(r-ct)\right).$$

The E_x & E_y above satisfy

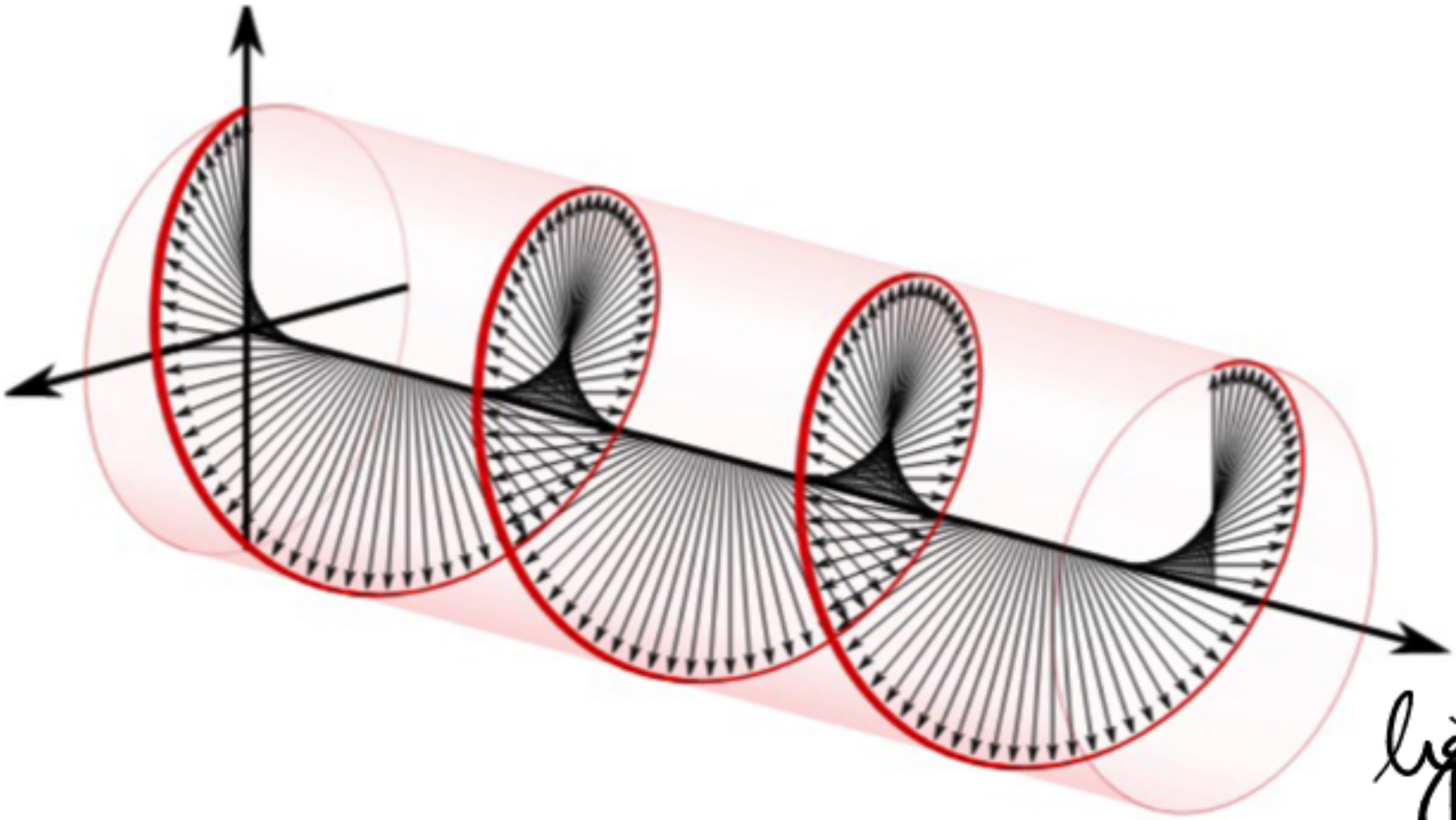
$$E_x^2 + E_y^2 = A_x^2.$$

Angle that the resultant vector makes with the x-axis

$$\tan\alpha = \frac{E_y}{E_x} = \mp \tan\left(\frac{2\pi}{\lambda}(r-ct)\right).$$

$$\Rightarrow \quad \alpha = \mp \frac{2\pi}{\lambda}(r-ct)$$

The angle the resultant E of constant magnitude A_x makes w/ the x-axis changes linealy with time.



light propagation direction.

Elliptically polarised light.

Light vector amplitude components along x- & y- axes.

$$\begin{pmatrix} A_x \\ \pm i A_y \end{pmatrix}$$

$$E_x = A_x \cos\left(\frac{2\pi}{\lambda}(r-ct)\right)$$

$$E_y = A_y \sin\left(\frac{2\pi}{\lambda}(r-ct)\right)$$

$$\Rightarrow \frac{E_x^2}{A_x^2} + \frac{E_y^2}{A_y^2} = 1.$$

Phase angle depends also on E_y/E_x.

Plane polarizer.

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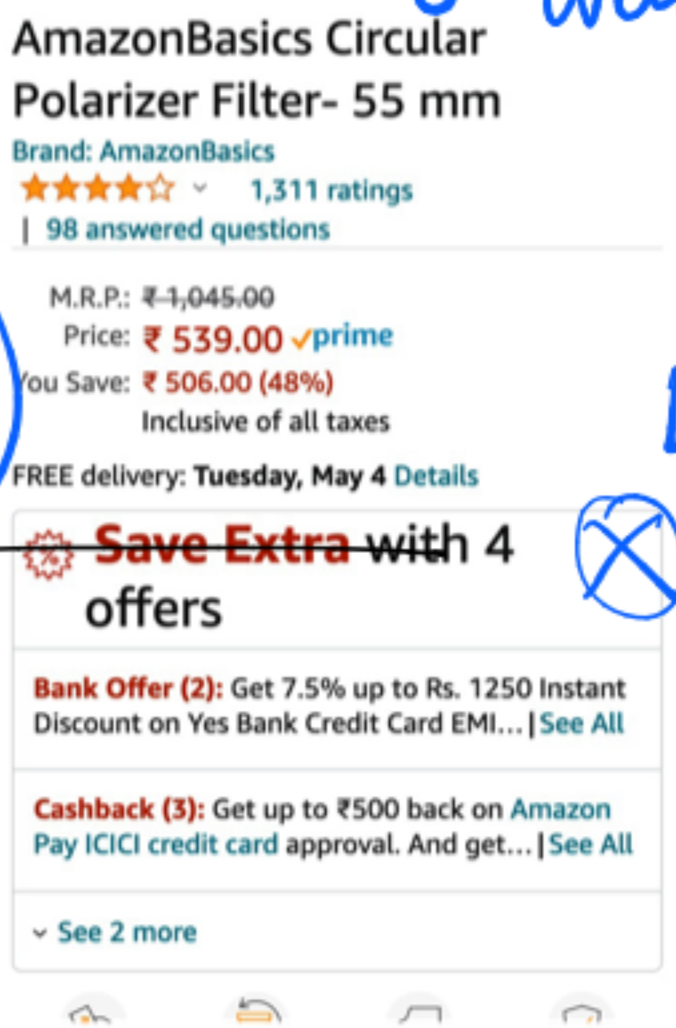
P = polarising axis of the polarising sheet

Incident light wave.

$\begin{pmatrix}A_x\\A_y\end{pmatrix}$

L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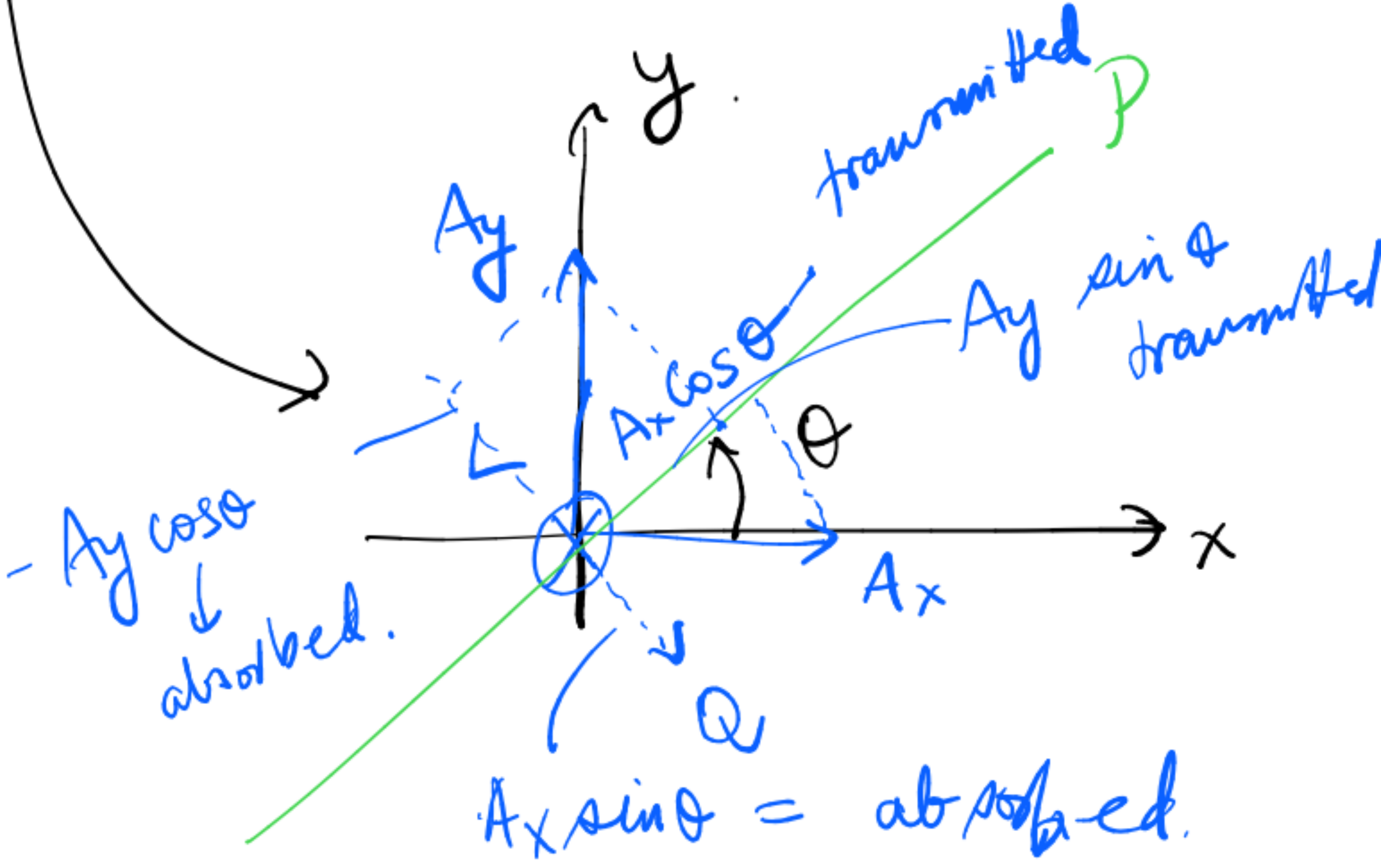


Emerging light will have electric field amplitude

$$\overset{\text{emerging}}{A'_p} = A_x \cos\theta + \overset{\text{incident}}{A_y} \sin\theta$$

along the polarizer axis. P

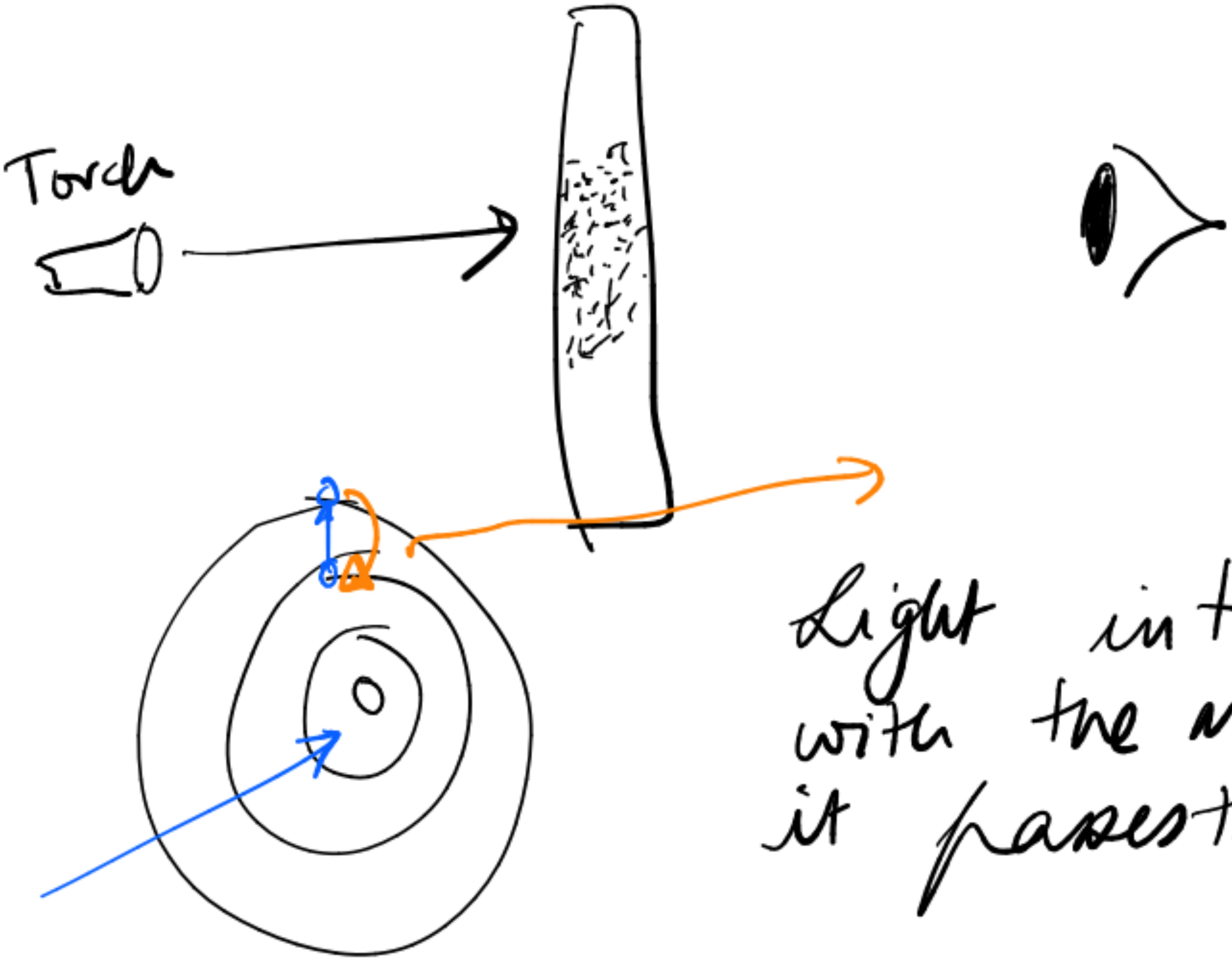
Components of the emerging light vector along the x- & y- axes $= \begin{pmatrix} A'_p \cos\theta \\ A'_p \sin\theta \end{pmatrix}$.

$$\Rightarrow \begin{pmatrix} A'_x \\ A'_y \end{pmatrix} = \underbrace{\begin{pmatrix} \cos^2\theta & \sin\theta\cos\theta \\ \sin\theta\cos\theta & \sin^2\theta \end{pmatrix}}_{P_\theta \,=\, \text{polarizer matrix.}} \begin{pmatrix} A_x \\ A_y \end{pmatrix}$$

Common polarizer orientation is w/ $\theta = \pi/4$.

$$P_\theta = \frac{1}{2}\begin{pmatrix} 1 & 1 \\ 1 & 1 \end{pmatrix}$$

Light in media other than vacuum.



Light interacts with the media it passes through.

Light travels slowly in non- vacuum media.

Speed of light in a medium = $\frac{c}{n}$,

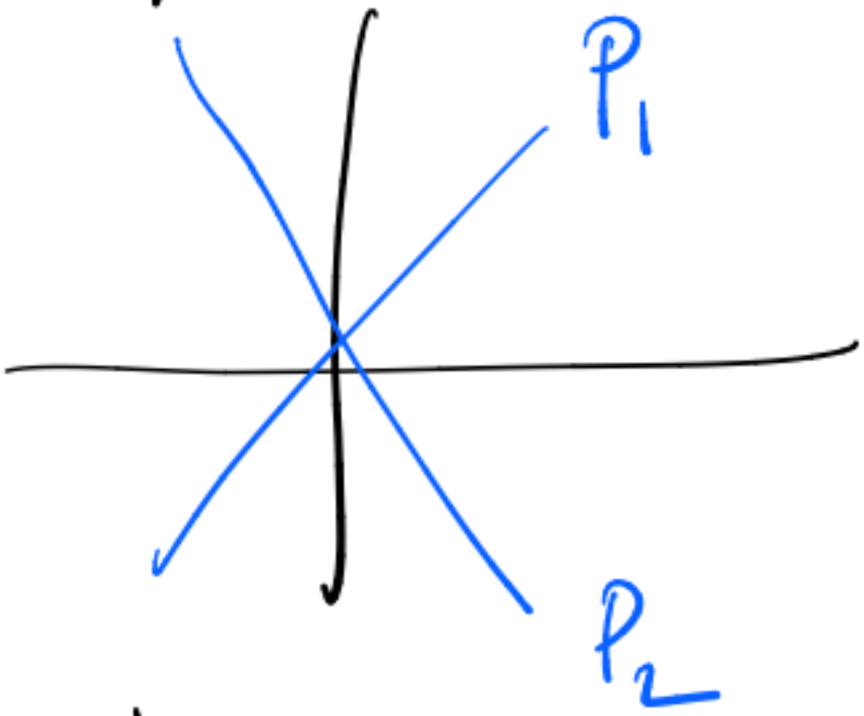
where n = refractive index of the medium.

$n = 1.3$ for water

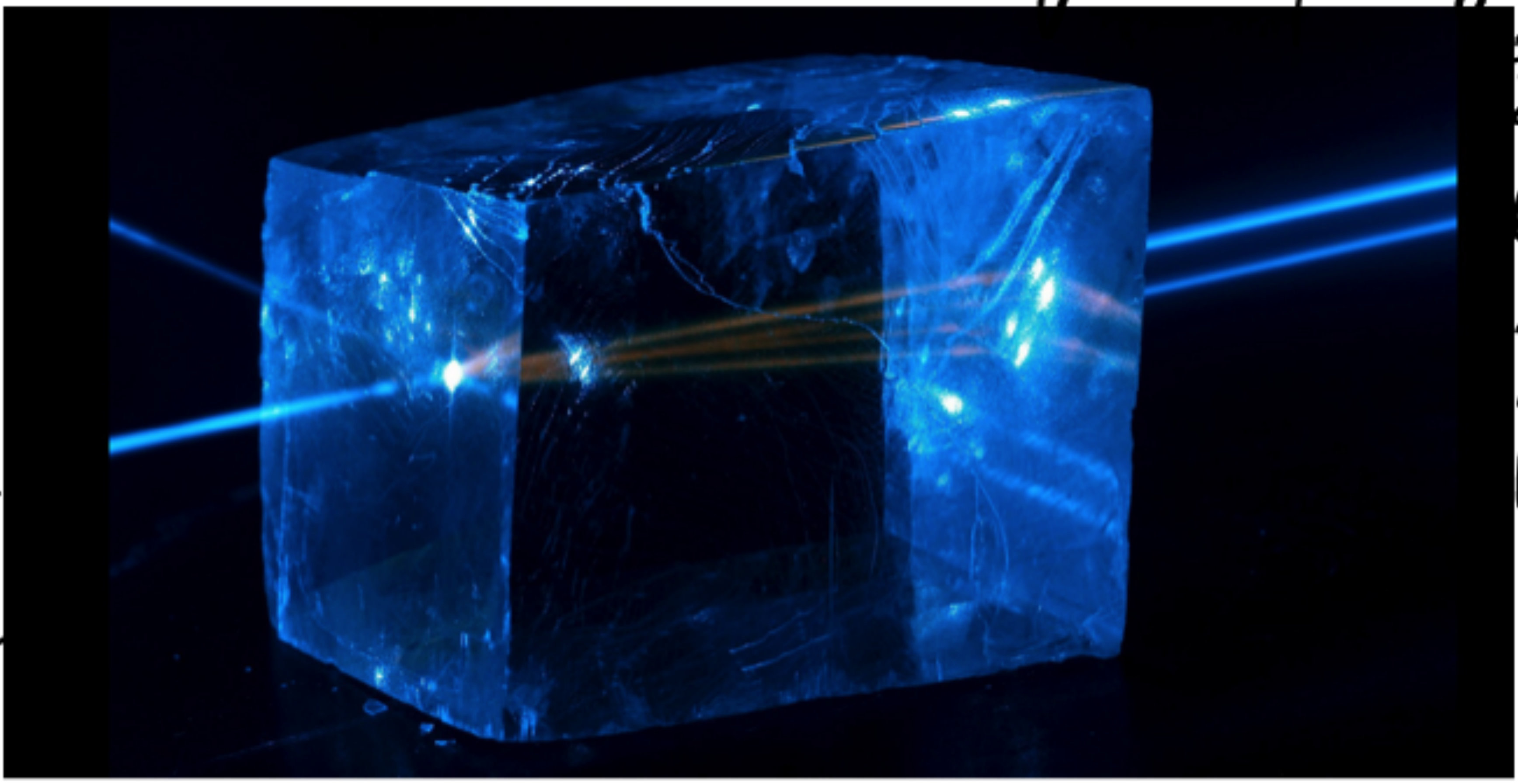
$n = 1.5$ for glass.

Birefringence.

Water is an isotropic transmitter of light ⇒ The speed of light in water does not depend on the polarization of light.



Calcite crystal: Speed of light / refractive index depends also on light polarization.



The incident beam is split into multiple(2) emergent beams

— Light travels through calcite with difft. speeds depending on polarization.

Many non-crystalline transparent materials are optically isotropic (like water) when unloaded. When loaded, however, they become anisotropic along the principal axes $\sigma_1, \sigma_2, \sigma_3$ of the stress tensor.

This phenomenon is called temporary or artificial birefringence.