PHY385-H1F Introductory Optics

Class 16 – Outline: Sections 8.1 to 8.4

- Linear Polarization
- Circular Polarization
- Elliptical Polarization
- "Unpolarized" Light
- Dichroism and Polarizers
- Birefringence

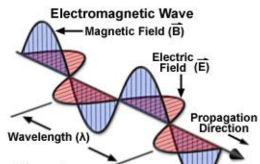
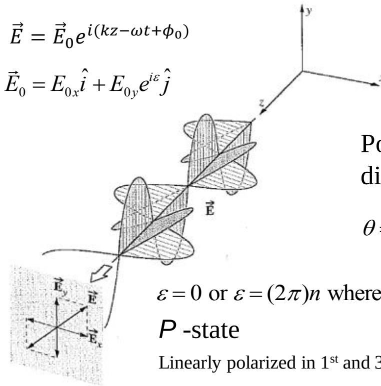


Figure 1

Question: What is the polarization direction of the wave shown above?
1. Horizontal
2. Vertical

$\vec{E} = \vec{E}_0 e^{i(kz-\omega t+\phi_0)}$

$\vec{E}_0 = E_{0x}\hat{i} + E_{0y}e^{i\varepsilon}\hat{j}$



Polarization direction:

$$\theta = \tan^{-1}\left(\frac{E_{0y}}{E_{0x}}\right)$$

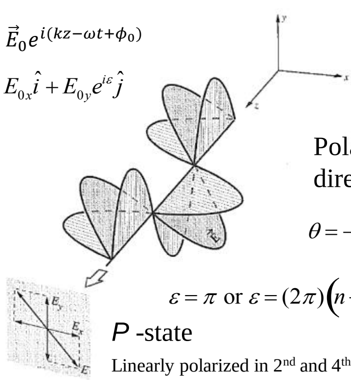
$\varepsilon = 0$ or $\varepsilon = (2\pi)n$ where $n = 0, \pm1, \pm2, \ldots$

P -state

Linearly polarized in 1st and 3rd quadrants.

$\vec{E} = \vec{E}_0 e^{i(kz-\omega t+\phi_0)}$

$\vec{E}_0 = E_{0x}\hat{i} + E_{0y}e^{i\varepsilon}\hat{j}$



Polarization direction:

$$\theta = -\tan^{-1}\left(\frac{E_{0y}}{E_{0x}}\right)$$

$\varepsilon = \pi$ or $\varepsilon = (2\pi)\left(n + \tfrac{1}{2}\right)$

P -state

Linearly polarized in 2nd and 4th quadrants.

$$\vec{E} = \vec{E}_0 e^{i(kz-\omega t+\phi_0)}$$

$$\vec{E}_0 = E_{0x}\hat{i} + E_{0y}e^{i\varepsilon}\hat{j}$$

If both E_{0x} and E_{0y} are nonzero, and $\varepsilon = 0$, this means the light is

1. Linear polarized along *x* or *y*
2. Linear polarized along a diagonal (neither *x* nor *y*)
3. Circular polarized
4. Elliptical polarized

$$\vec{E} = \vec{E}_0 e^{i(kz-\omega t+\phi_0)}$$

$$\vec{E}_0 = E_{0x}\hat{i} + E_{0y}e^{i\varepsilon}\hat{j}$$

If both E_{0x} and E_{0y} are nonzero, and $\varepsilon = +0.1$, this means

1. The *y*-component of the oscillations reaches its maximum slightly after the *x*-component
2. The *y*-component of the oscillations reaches its maximum slightly before the *x*-component
3. There is an exponential decay in the *y*-component of the oscillations
4. The *y*-component of the oscillations is imaginary

$$\vec{E} = \vec{E}_0 e^{i(kz-\omega t+\phi_0)}$$

$$\vec{E}_0 = E_{0x}\hat{i} + E_{0y}e^{i\varepsilon}\hat{j}$$

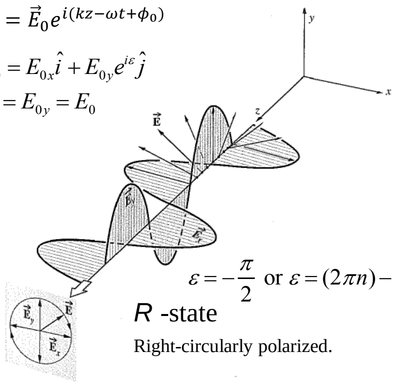
If both E_{0x} and E_{0y} are nonzero, and $\varepsilon = -0.1$, this means

1. The *y*-component of the oscillations reaches its maximum slightly after the *x*-component
2. The *y*-component of the oscillations reaches its maximum slightly before the *x*-component

$\vec{E} = \vec{E}_0 e^{i(kz-\omega t+\phi_0)}$

$\vec{E}_0 = E_{0x}\hat{i} + E_{0y}e^{i\varepsilon}\hat{j}$

$E_{0x} = E_{0y} = E_0$



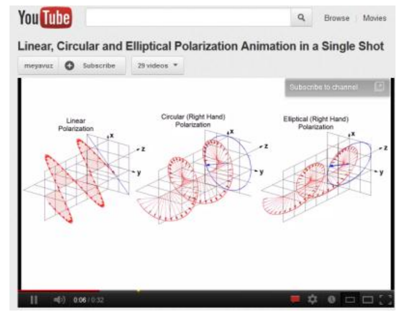
$\varepsilon = -\frac{\pi}{2}$ or $\varepsilon = (2\pi n) - \pi/2$

R -state

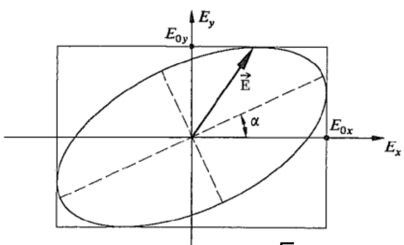
Right-circularly polarized.

Video of Linear, Circular, Elliptical Polarizations

http://www.youtube.com/watch?feature=fvwp&v=Q0qrU4nprB0&NR=1



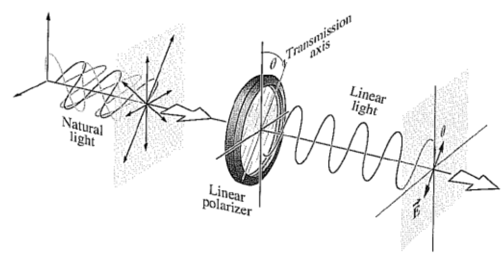
Elliptical polarization



E -state

Elliptically polarized.
Elliptical polarization is the most general form of polarized light.
Linear and circular are special cases.

Dichroism



"Unpolarized" light incident on a linear polarizer tilted at an angle θ with respect to the vertical

Birefringence

$n_x \neq n_y$