Opto-Electronics and Photonics

Lecture 5: Polarization

Woo-Young Choi

Dept. of Electrical and Electronic Engineering
Yonsei University

Lecture 5: Polarization

(8-2.3 in Cheng)

Polarization (Lecture 2)

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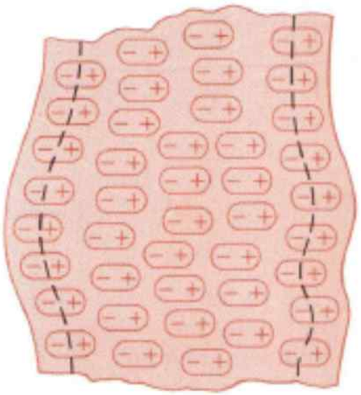


Polarization:

How E-, H-field directions change with time

편광 (偏光)

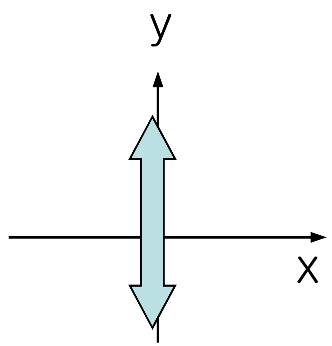
Lecture 5: Polarization

Consider $\overline{E} = \left(\overline{x}E_1 + \overline{y}E_2\right)e^{jkz}e^{j\omega t}$

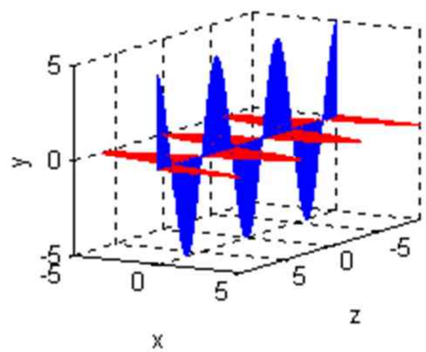
How does E-field direction change in time?

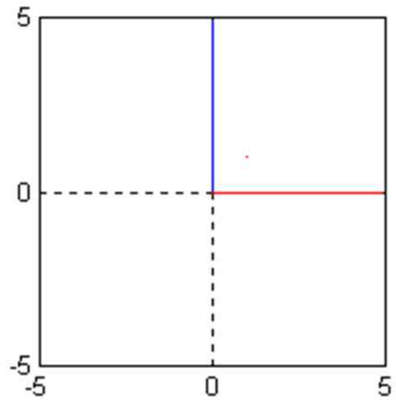
Let z=0 $\mathrm{Re}\left[\overline{E}\right] = \overline{x}E_1\cos(\omega t) + \overline{y}E_2\cos(\omega t)$

1) If E_1=0 : $\mathrm{Re}\left[\overline{E}\right] = \overline{y}E_2\cos(\omega t)$



Linear polarization



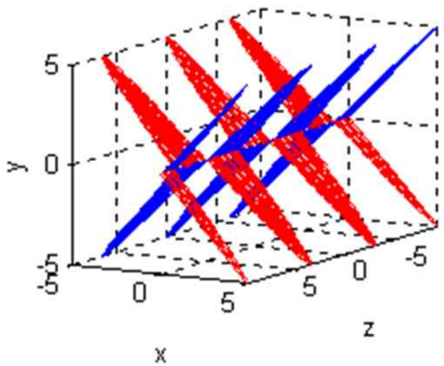


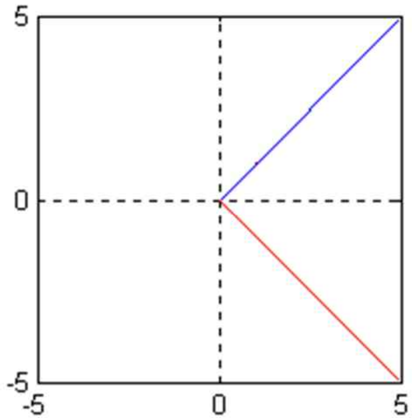
Lecture 5: Polarization

$$\overline{E} = \left(\overline{x}E_1 + \overline{y}E_2\right)e^{jkz}e^{j\omega t}$$

2) $E_1 = E_2$ $\quad \overline{E} = \left(\overline{x} + \overline{y}\right)E_1 e^{jkz}e^{j\omega t}$

At z= 0, $\mathrm{Re}\left[\overline{E}\right] = \overline{x}E_1\cos\left(\omega t\right) + \overline{y}E_1\cos(\omega t)$





Linear Polarization

Lecture 5: Polarization

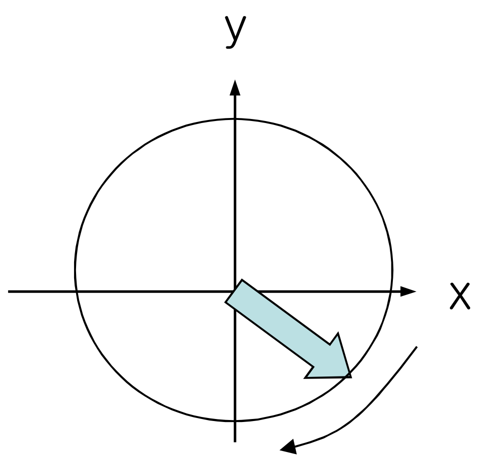
$$\overline{E} = \left(\overline{x}E_1 + \overline{y}E_2\right)e^{jkz}e^{j\omega t}$$

3) $E_2 = j\,E_1$ $\qquad \overline{E} = \left(\overline{x} + \overline{y}j\right)E_1 e^{jkz}e^{j\omega t}$

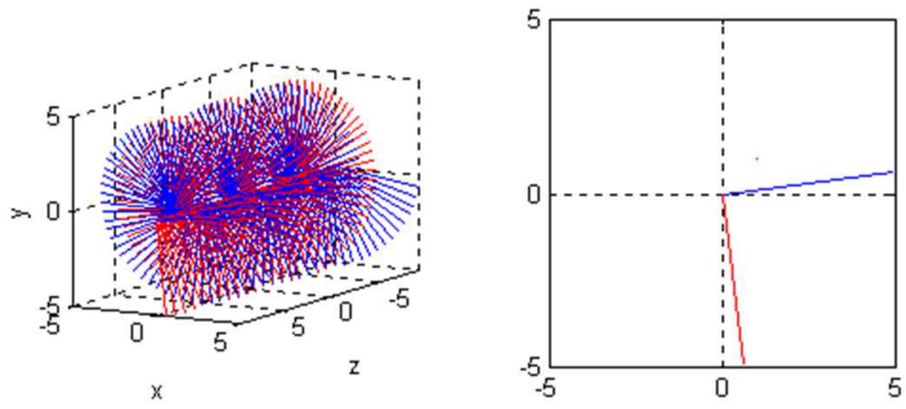
At z=0,

$$\mathrm{Re}(\overline{E}) = \mathrm{Re}\left[E_1\left(\overline{x}e^{j\omega t} + \overline{y}e^{j(\omega t+\pi/2)}\right)\right] = E_1\left\{\overline{x}\cos(\omega t) + \overline{y}\cos(\omega t + \pi/2)\right\}$$

$$= E_1\left\{\overline{x}\cos(\omega t) - \overline{y}\sin(\omega t)\right\}$$



Circular polarization



Right-Handed Circular Polarization (RHCP)

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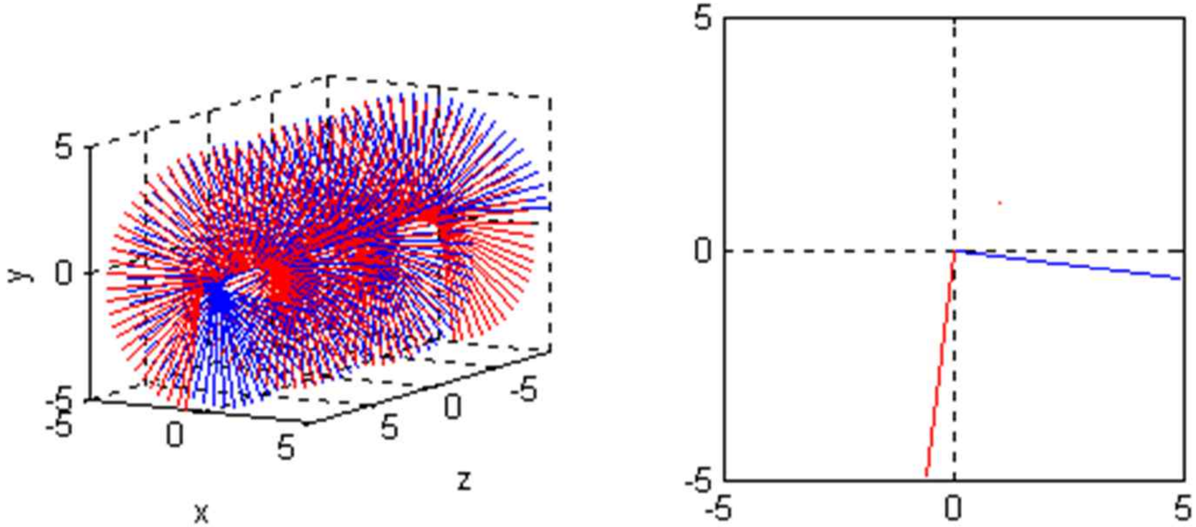
$$\overline{E} = \left(\overline{x} + \overline{y}j\right)E_1 e^{jkz} e^{j\omega t} ==> E_1\left\{\overline{x}\cos(\omega t) - \overline{y}\sin(\omega t)\right\} \quad \text{RHCH}$$

$$\overline{E} = \left(\overline{x} - \overline{y}j\right)E_1 e^{jkz} e^{j\omega t}$$

At z=0, $\mathrm{Re}(\overline{E}) = E_1\left\{\overline{x}\cos(\omega t) + \overline{y}\sin(\omega t)\right\}$



Left-Handed Circular Polarization (LHCP)

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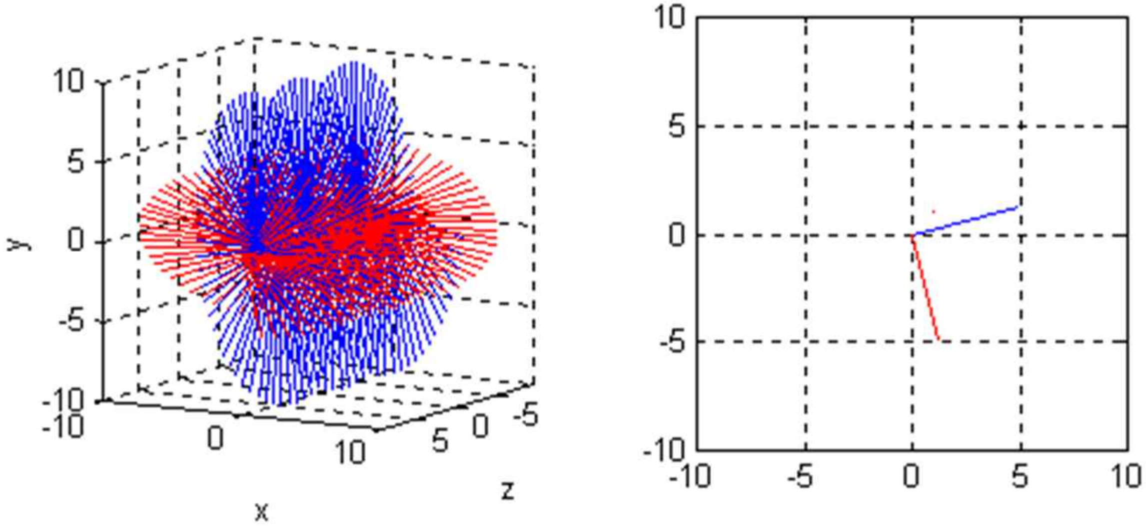
4) If $E_1 < E_2$

$$\overline{E} = \left(\overline{x}E_1 + \overline{y}jE_2\right)e^{jkz}e^{j\omega t}$$



Right-Handed Elliptical Polarization

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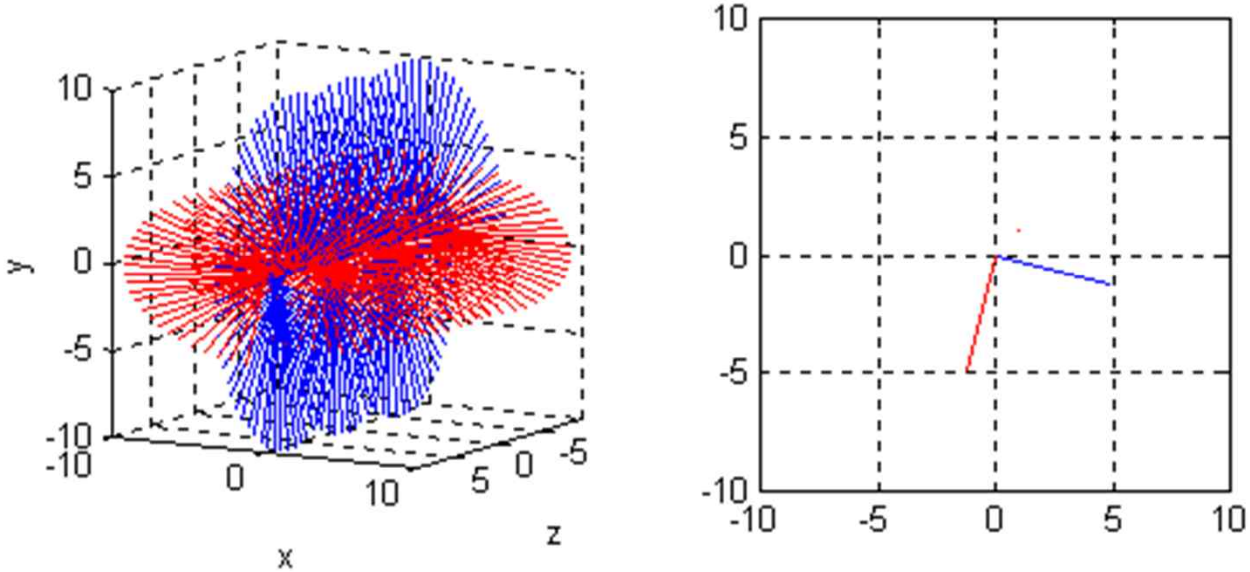
$$\overline{E} = \left(\overline{x}E_1 - \overline{y}\,jE_2\right)e^{jkz}e^{j\omega t}$$



Left-Handed Elliptical Polarization

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$$\overline{E} = \left(\overline{x}E_1 + \overline{y}E_2\right)e^{jkz}e^{j\omega t}$$

$$E_1 = |E_1|\exp(j\theta_1),\ E_2 = |E_2|\exp(j\theta_2)$$

If $\theta_1 = \theta_2$, linear

else if $(|E_1| = |E_2|$ and $|\theta_2 - \theta_1| = \pi/2)$, circular

otherwise elliptical

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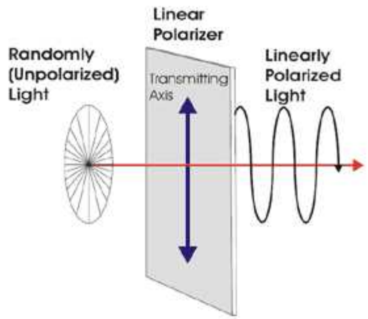
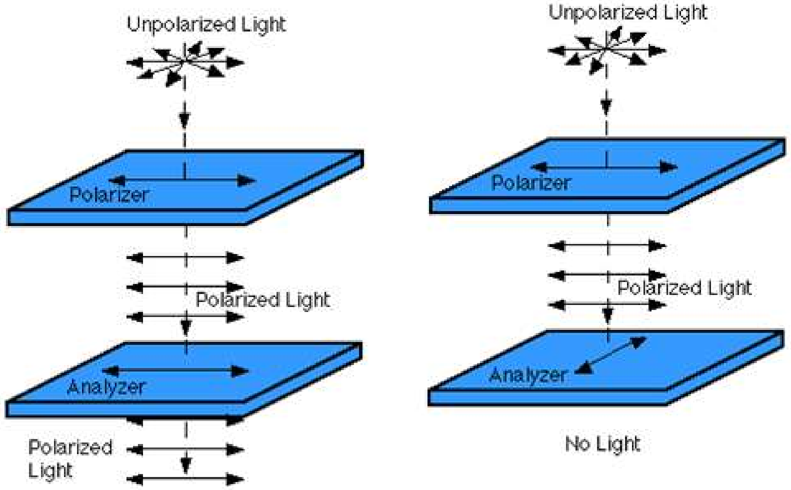
Polarization is an important property of EM waves

Polarization Filters

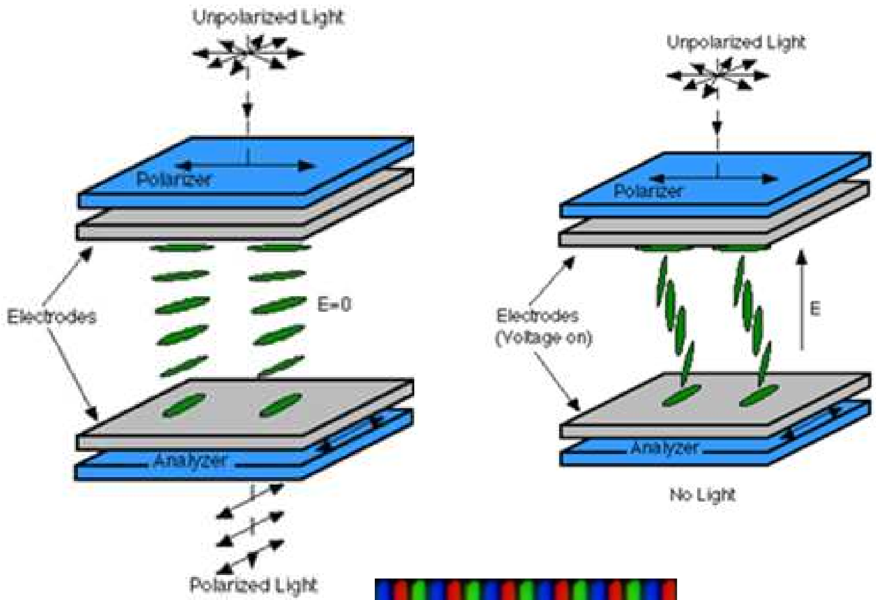


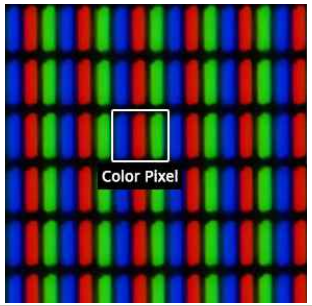
Lecture 5: Polarization

Turning on/off light transmission



Liquid Crystal Display





Lecture 5: Polarization

Homework (Due 9/20)

(1) What is the polarization of $\overline{E} = \left(\overline{x} + \overline{y}\right) E_0 e^{-jkz} e^{j\omega t}$?

(2) What is the polarization of $\overline{E} = \left(\overline{x} j + \overline{y}\right) E_0 e^{-jkz} e^{j\omega t}$?

(3) What is the polarization of $\overline{E} = \left(\overline{x} j + \dfrac{\overline{y} - \overline{z}}{\sqrt{2}}\right) E_0 e^{-j\frac{k}{\sqrt{2}}y} e^{-j\frac{k}{\sqrt{2}}z} e^{j\omega t}$?

(4) Show that a linearly polarized plane wave can be expressed as a sum of RHC and LHC waves