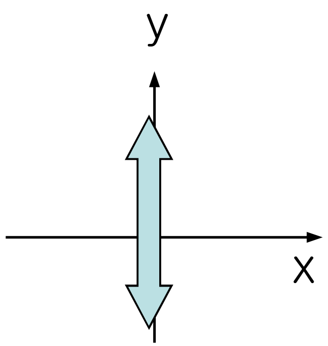
Lecture 2: Electro-Magnetic Waves

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

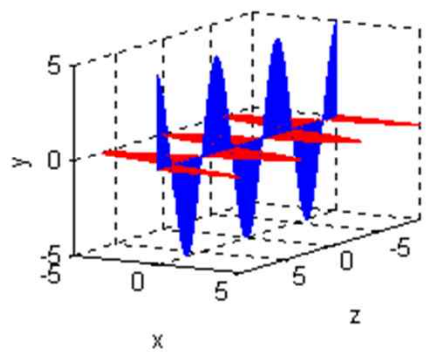
How does E-field direction change in time?

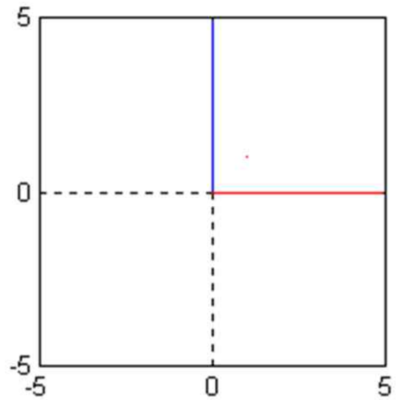
Let z=0 $\mathrm{Re}\left[\overline{E}\right] = \overline{x}E_1\cos(\omega t) + \overline{y}E_2\cos(\omega t)$

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



Linear polarization



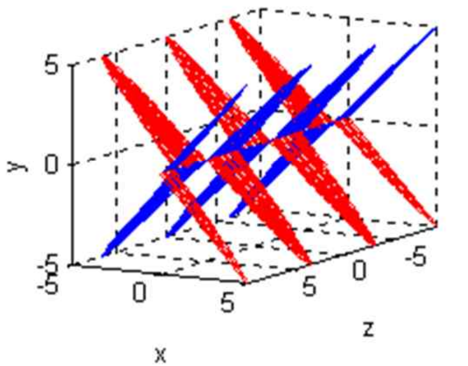


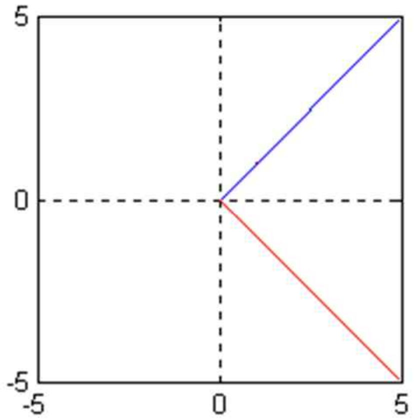
Lecture 2: Electro-Magnetic Waves

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

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

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





Linear Polarization

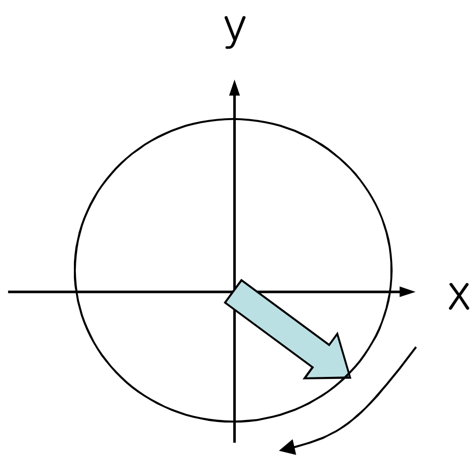
$$\overline{E} = \left(\overline{x}E_1 + \overline{y}E_2\right)e^{jkz}e^{j\omega t}$$

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

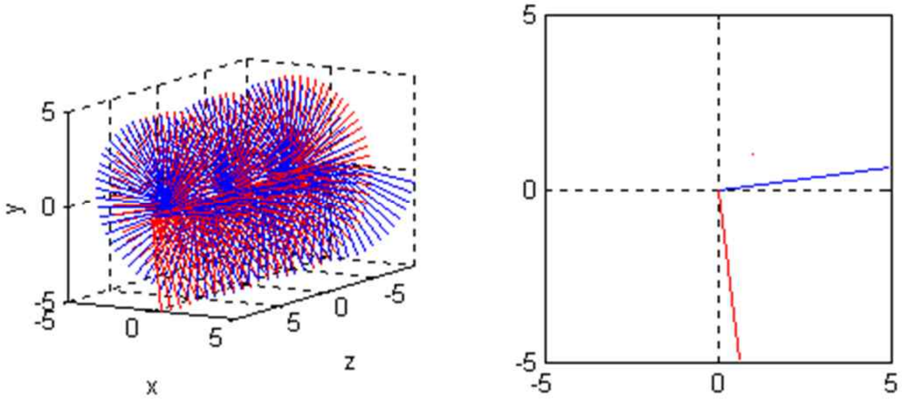
At z = 0,

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

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



Circular polarization



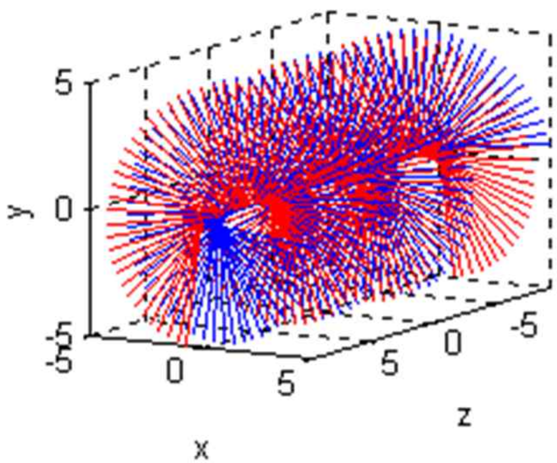
Right-Handed Circular Polarization (RHCP)

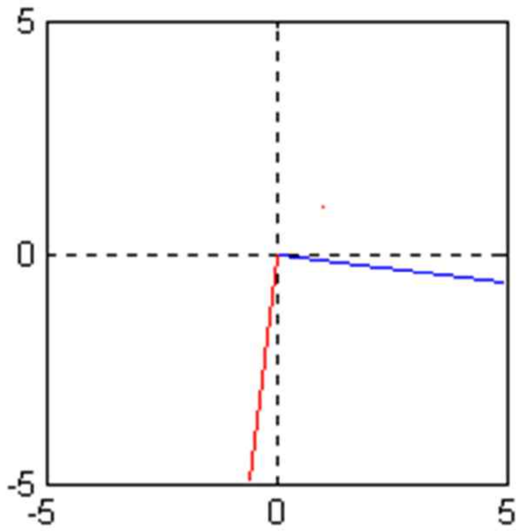
Lecture 2: Electro-Magnetic Waves

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

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

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



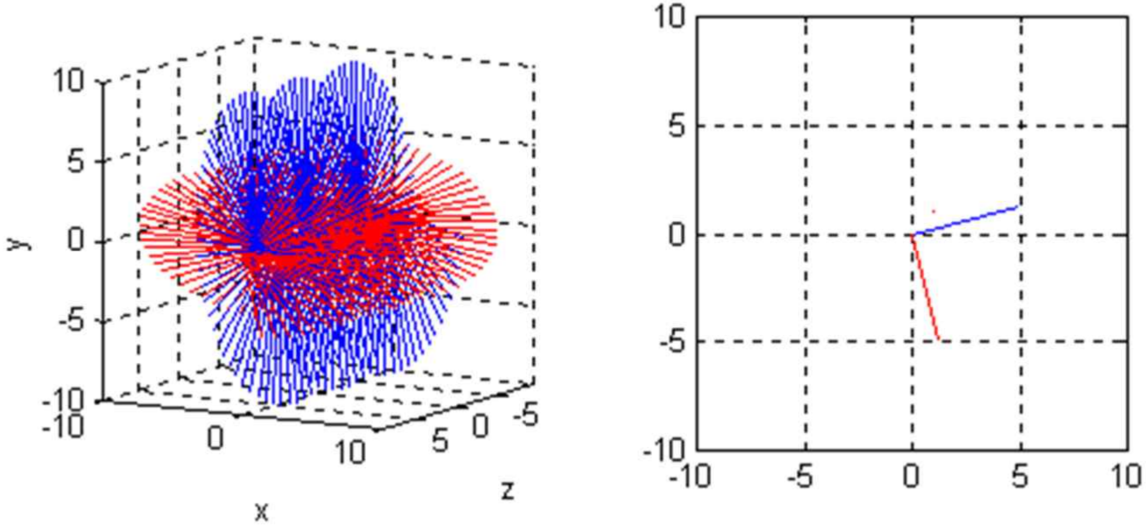


Left-Handed Circular Polarization (LHCP)

Lecture 2: Electro-Magnetic Waves

4) If $E_1 < E_2$

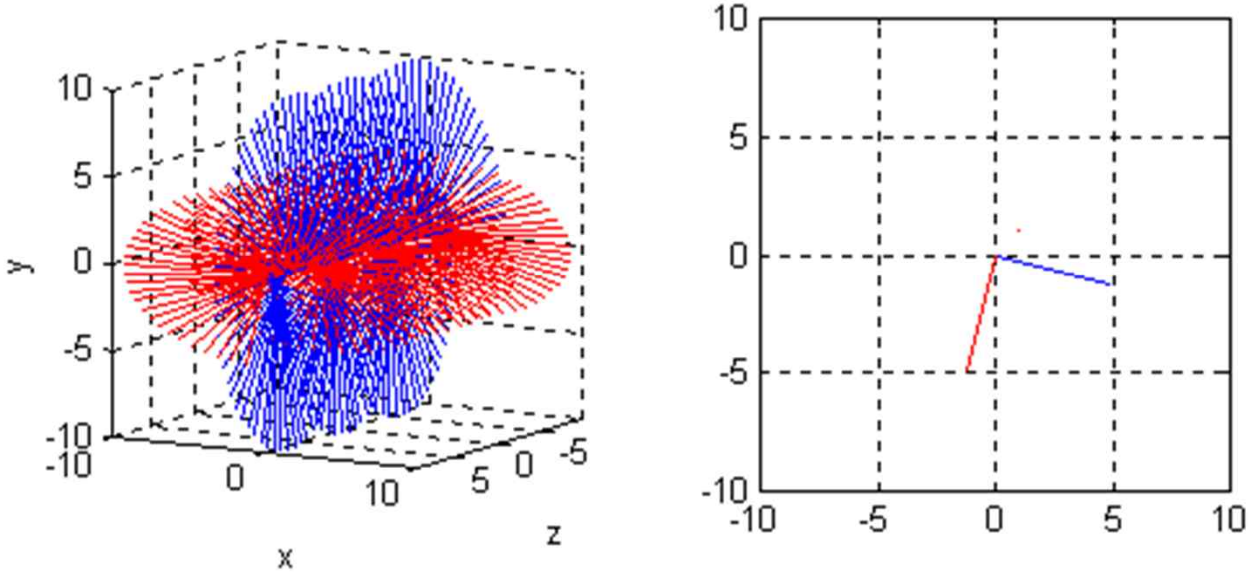
$$\overline{E} = \left(\overline{x}E_1 + \overline{y}\,jE_2\right)e^{jkz}e^{j\omega t}$$



Right-Handed Elliptical Polarization

Lecture 2: Electro-Magnetic Waves

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



Left−Handed Elliptical Polarization

Lecture 2: Electro-Magnetic Waves

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

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

If $\theta_1 = \theta_2$, linear

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

otherwise elliptical