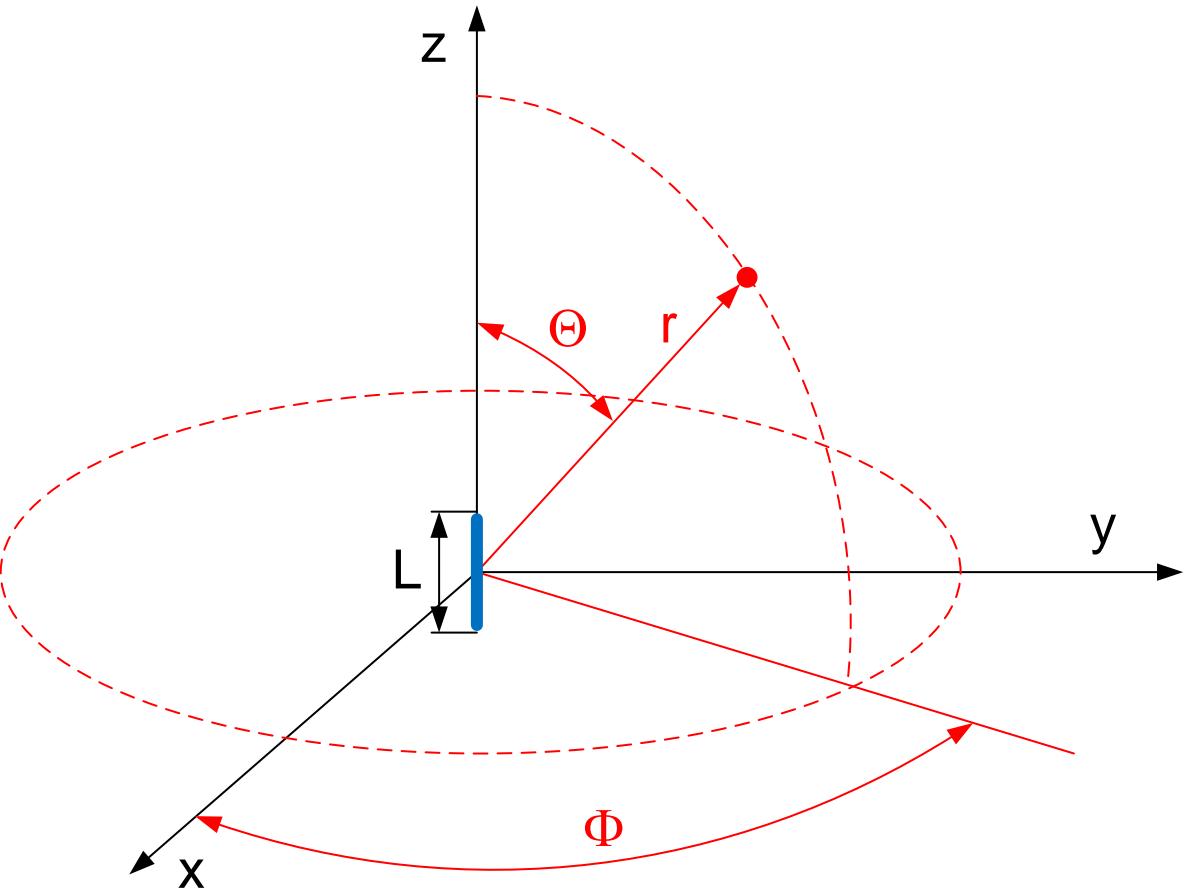
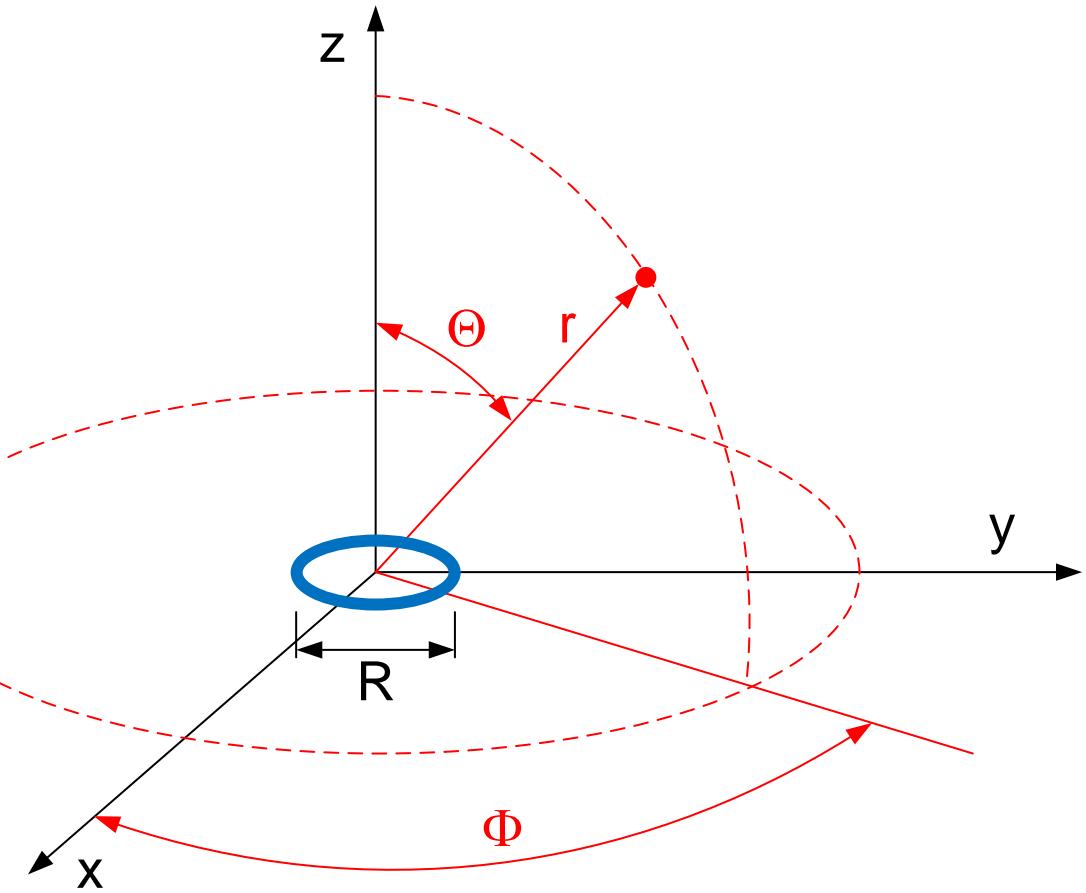


Two fundamental types of radiators:



Electric dipole



Magnetic loop

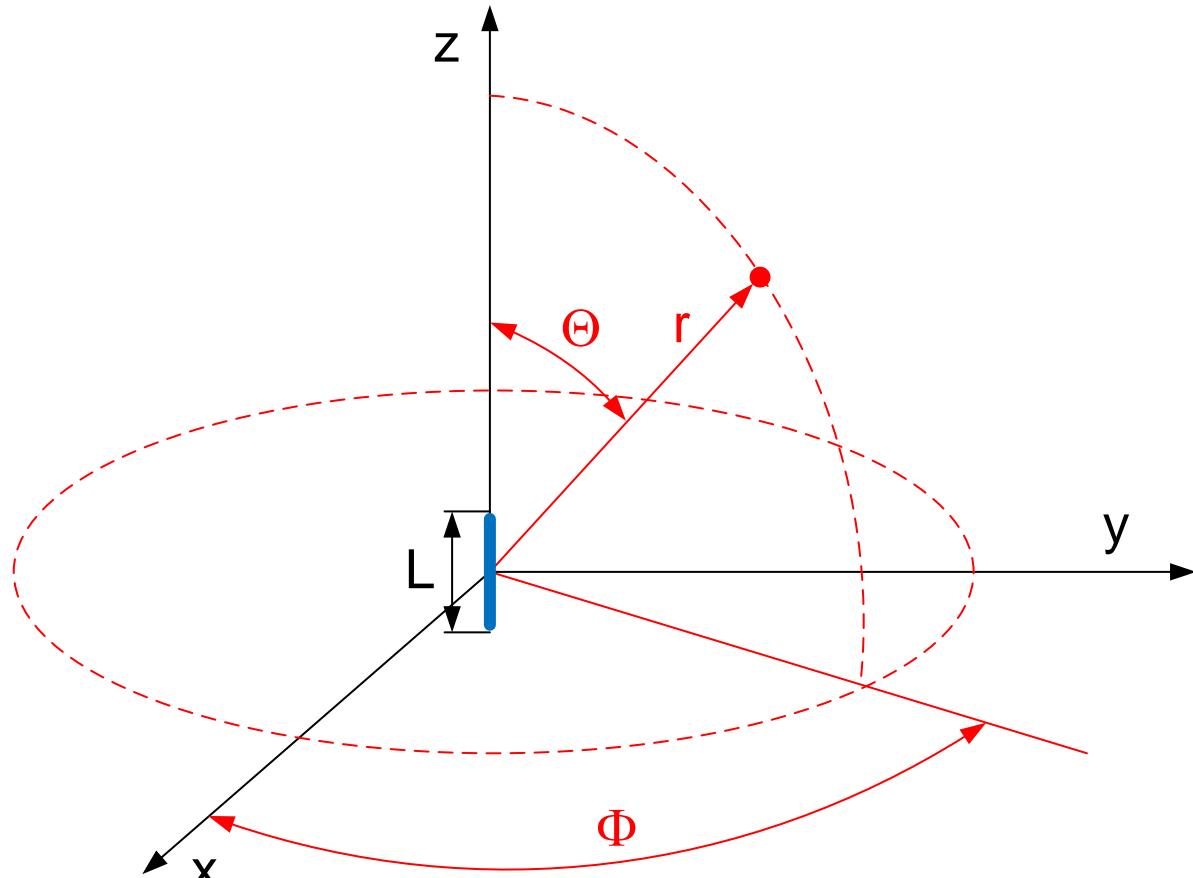
Electromagnetic field around an electric dipole

Three field components exist in a vicinity of a dipole:

$$E_r = \frac{Z_0}{2\pi} \frac{I_0 L \cos \Theta}{r^2} \left(1 + \frac{1}{jkr} \right) e^{-jkr}$$

$$E_\Theta = \frac{jZ_0 k}{4\pi} \frac{I_0 L \sin \Theta}{r} \left(1 + \frac{1}{jkr} - \frac{1}{(kr)^2} \right) e^{-jkr}$$

$$H_\Phi = \frac{jk}{2\pi} \frac{I_0 L \sin \Theta}{r} \left(1 + \frac{1}{jkr} \right) e^{-jkr}$$



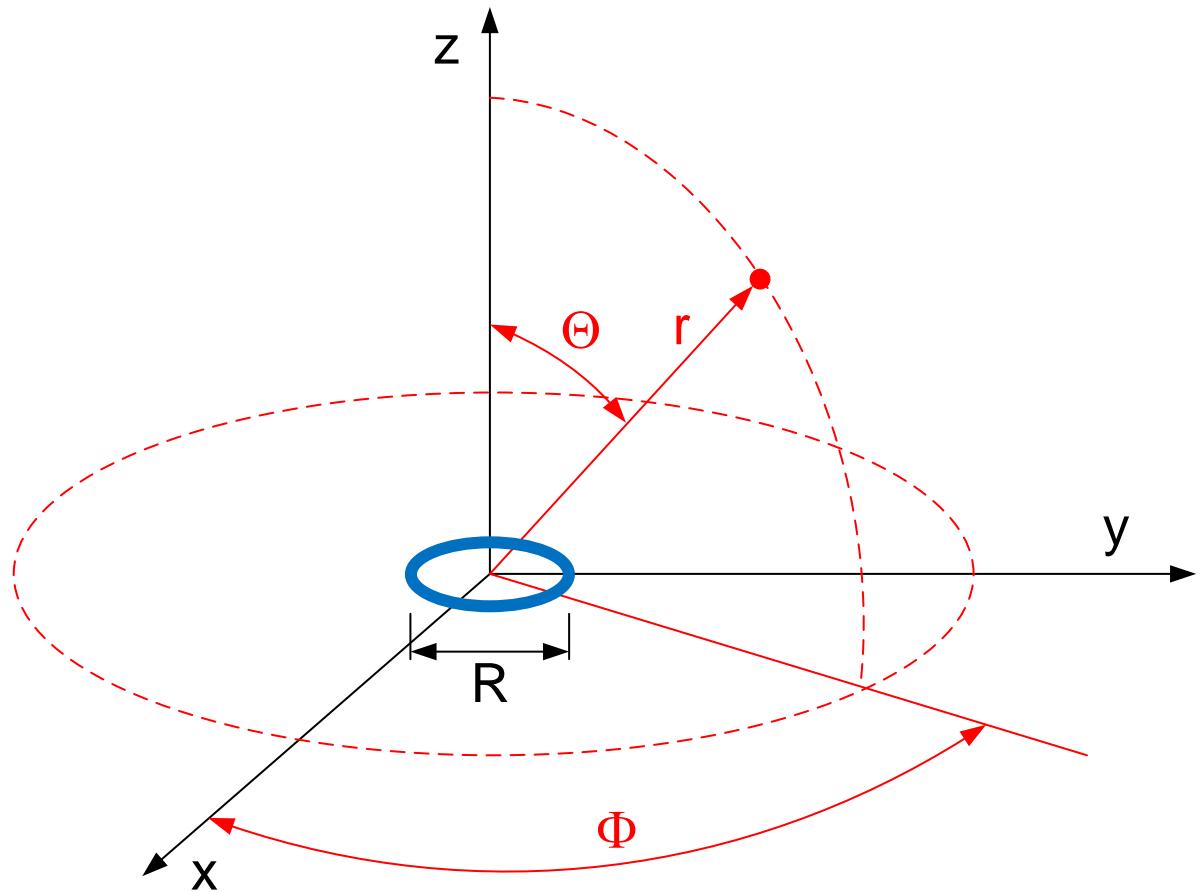
Wave number (m^{-1})

$$k = \frac{2\pi}{\lambda}$$

Impedance of free space (Ω)

$$Z_0 = \sqrt{\frac{\mu_0}{\epsilon_0}} \cong 377 \Omega$$

Electromagnetic field around a magnetic loop



Three field components exist in a vicinity of a loop:

$$H_r = \frac{jk}{2\pi} \frac{I_0 \pi R^2 \cos \Theta}{r^2} \left(1 + \frac{1}{jkr} \right) e^{-jkr}$$

$$H_\Theta = \frac{-k^2}{4\pi} \frac{I_0 \pi R^2 \sin \Theta}{r} \left(1 + \frac{1}{jkr} - \frac{1}{(kr)^2} \right) e^{-jkr}$$

$$E_\Phi = \frac{Z_0 k^2}{4\pi} \frac{I_0 \pi R^2 \sin \Theta}{r} \left(1 + \frac{1}{jkr} \right) e^{-jkr}$$

Observation:

E and H components swapped

Nominator: loop area, current magnitude

Denominator: distance from the source

Electromagnetic field around a magnetic loop

What does the math say?

$$H_r = \frac{jk}{2\pi} \frac{I_0 \pi R^2 \cos \Theta}{r^2} \left(1 + \frac{1}{jkr}\right) e^{-jkr} \propto k \left(\frac{1}{r^2} + \frac{1}{r^3}\right)$$

$$H_\Theta = \frac{-k^2}{4\pi} \frac{I_0 \pi R^2 \sin \Theta}{r} \left(1 + \frac{1}{jkr} - \frac{1}{(kr)^2}\right) e^{-jkr} \propto k \left(\frac{1}{r^1} + \frac{1}{r^2} + \frac{1}{r^3}\right)$$

$$E_\Phi = \frac{Z_0 k^2}{4\pi} \frac{I_0 \pi R^2 \sin \Theta}{r} \left(1 + \frac{1}{jkr}\right) e^{-jkr} \propto k \left(\frac{1}{r^1} + \frac{1}{r^2}\right)$$

Observation:

Intensity of the field components fall with distance from the object

Some diminish completely very quickly (e.g. H_r , E_r)

Other are dominant in very close vicinity (H_Θ for magnetic excitation, E_Φ for magnetic excitation)

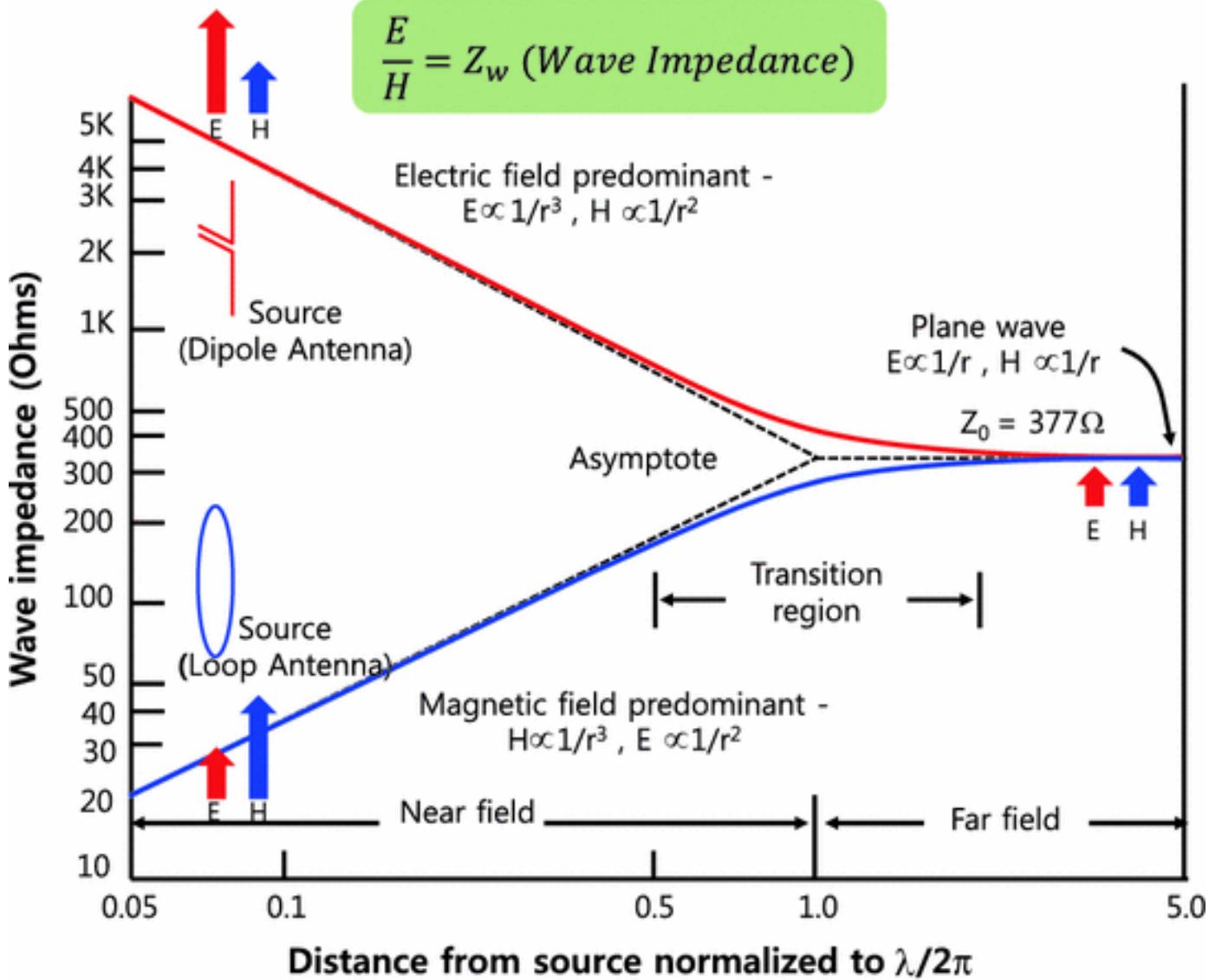
Finally, only the $1/r$ “survives” until the infinity



Definition of far/near fields

Field type	Zone	E	H	Power, energy	$Z_{WAVE} = E/H$
Excited by E-source	near	$E_\Theta \propto 1/r^3$	$H_\Phi \propto 1/r^2$	$\propto 1/r^5$	$Z_E \propto 1/r^1$
	far	$E_\Theta \propto 1/r^1$	$H_\Phi \propto 1/r^1$	$\propto 1/r^2$	$Z_E \approx Z_0 = 377 \Omega$
Excited by H-source	near	$E_\Phi \propto 1/r^2$	$H_\Theta \propto 1/r^3$	$\propto 1/r^5$	$Z_H \propto r^1$
	far	$E_\Phi \propto 1/r^1$	$H_\Theta \propto 1/r^1$	$\propto 1/r^2$	$Z_H \approx Z_0 = 377 \Omega$

Definition of far/near fields



Definition of far/near fields

In front of the building 864. What is value of Z_{WAVE} ? In which zone are we?

