Field Regions and Power Pattens of Infinitesimal Dipole

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http://dspandlinux.com

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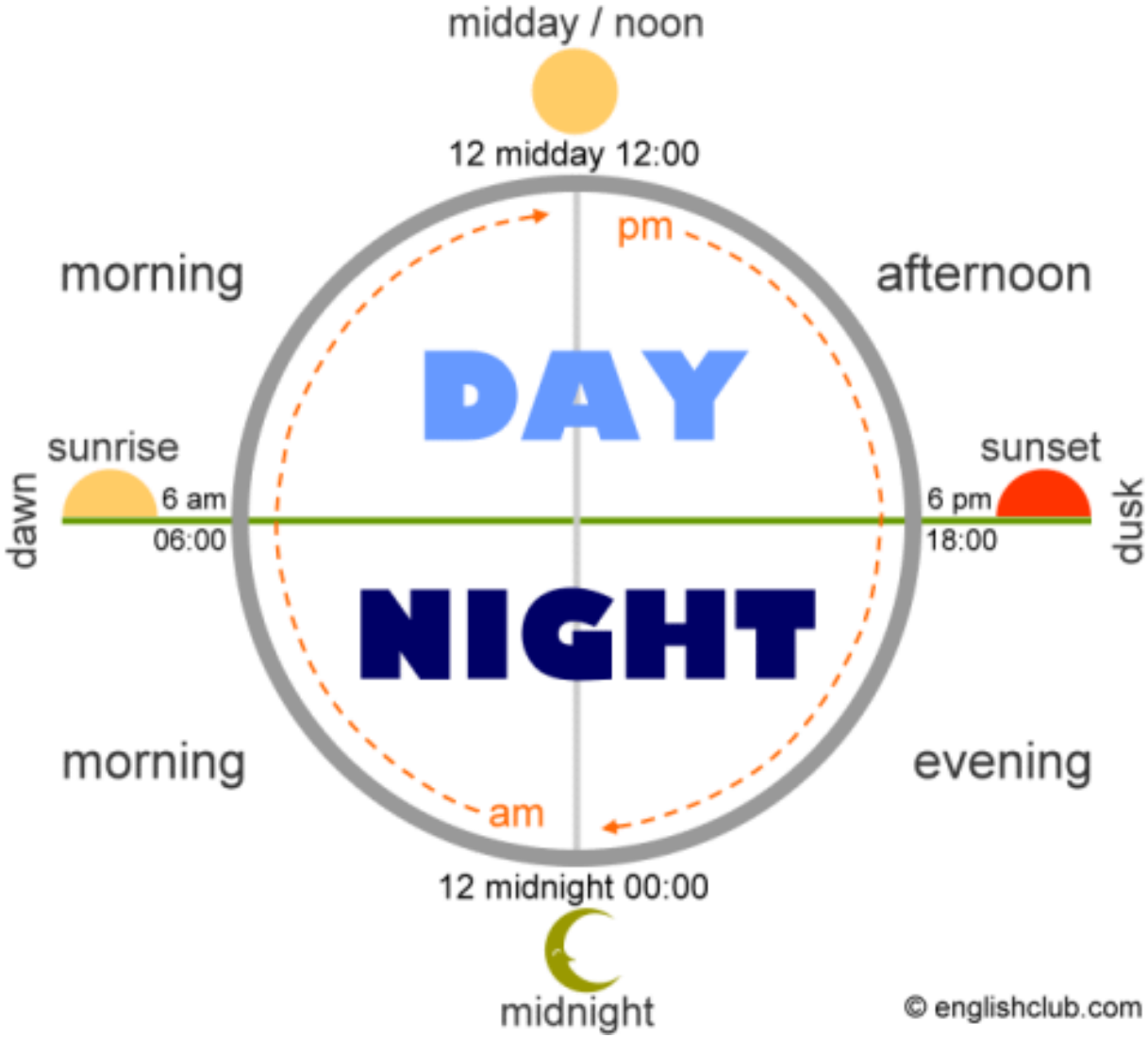
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pm
morning
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sunrise
6 am
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dawn
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dusk
NIGHT
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evening
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12 midnight 00:00
midnight
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Antenna radiation zoning

Infinitesimal Dipole($l \ll \lambda$)

- Near-Field (kr$\ll$1)
- Intermediate-Field (kr$>$1)
- Far-Field (kr$\gg$1)

Why ?

How ?

What ?

Outline

E

$$E_r = \eta \frac{I_0 l \cos\theta}{2\pi r^2}[1 + \frac{1}{jkr}]e^{-jkr}$$

$$E_\theta = j\eta \frac{kI_0 l \sin\theta}{4\pi r}[1 + \frac{1}{jkr} - \frac{1}{(kr)^2}]e^{-jkr}$$

$$E_\phi = 0$$

H

$$H_r = H_\theta = 0$$

$$H_\phi = j \frac{kI_0 l \sin\theta}{4\pi r}[1 + \frac{1}{jkr}]e^{-jkr}$$

Outline

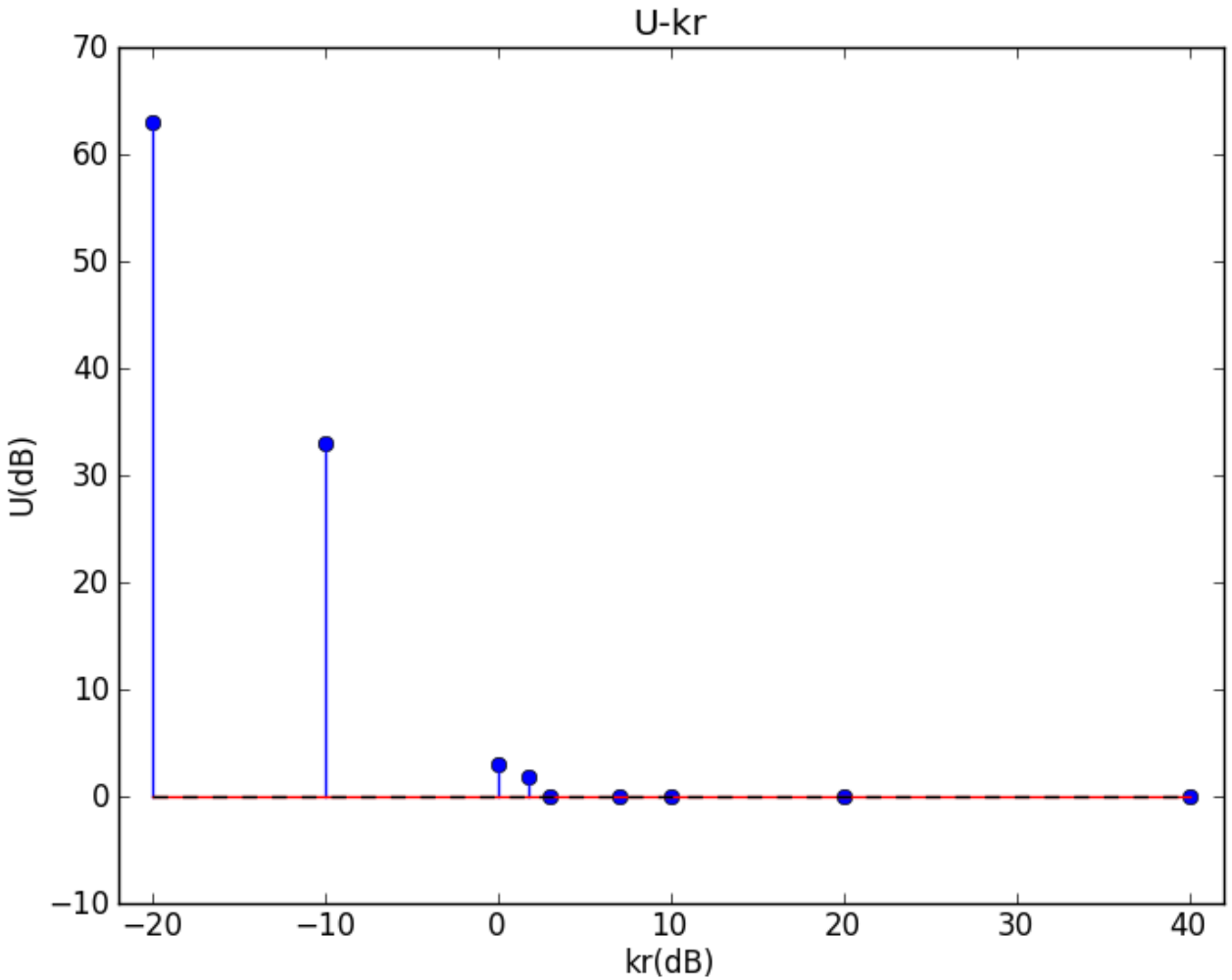
Poynting vector

$$\begin{aligned}\mathbf{W} &= \tfrac{1}{2}(\mathbf{E}\times\mathbf{H}^*) = \tfrac{1}{2}(\hat{a}_r E_r + \hat{a}_\theta E_\theta)\times(\hat{a}_\phi H_\phi^*) \\ &= \tfrac{1}{2}(\hat{a}_r E_\theta H_\phi^* - \hat{a}_\phi E_r H_\phi^*)\end{aligned}$$

Power

$$\begin{aligned}P &= \tfrac{1}{2}\iint_s \mathbf{E}\times\mathbf{H}^*\cdot d\mathbf{s} = \eta(\tfrac{\pi}{3})|\tfrac{I_0 l}{\lambda}|^2[1 - j\tfrac{1}{(kr)^3}] \\ &= P_{rad} + j2\omega(\tilde{W}_m - \tilde{W}_e)\end{aligned}$$

Outline



Near-Field Region

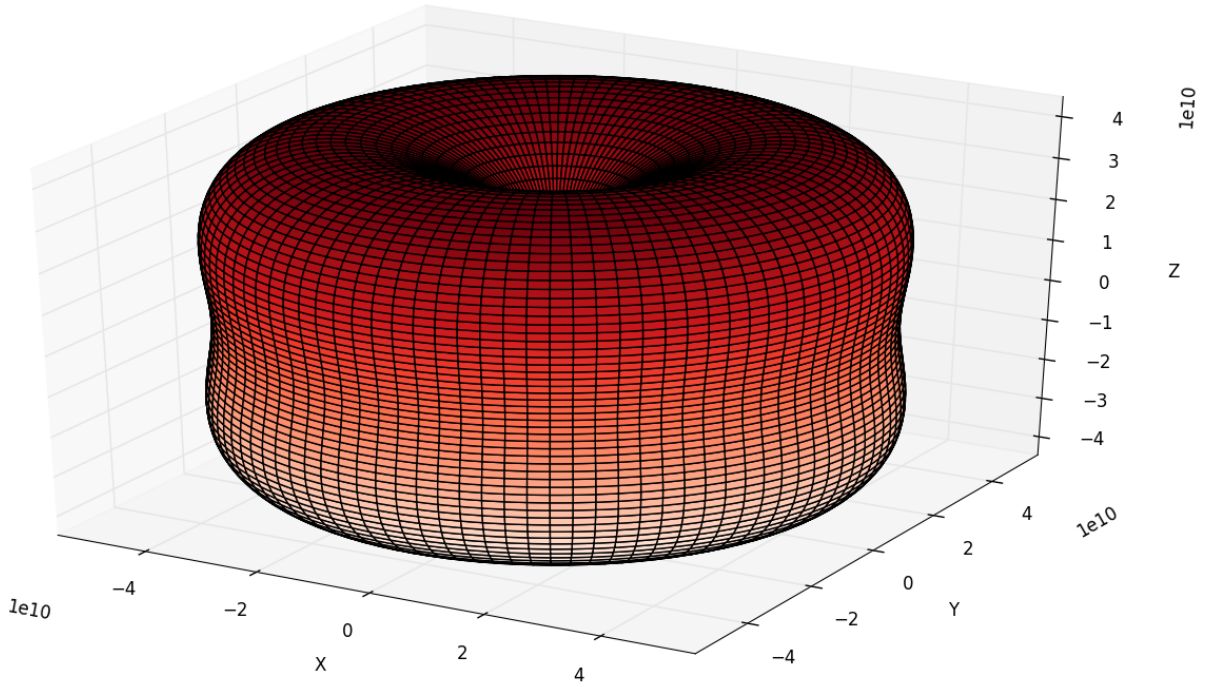
$$\left.\begin{aligned} E_r &\simeq -j\eta \frac{I_0 l e^{-jkr}}{2\pi k r^3} \cos\theta \\ E_\theta &\simeq -j\eta \frac{I_0 l e^{-jkr}}{1\pi k r^3} \sin\theta \\ E_\phi &= H_r = H_\theta = 0 \\ H_\phi &\simeq \frac{I_0 l e^{-jkr}}{4\pi r^2} \sin\theta \end{aligned}\right\} \quad kr \ll 1 \tag{1}$$

$$\text{if} \quad f = 10GHz, kr = 0.1, \text{then}$$

$$k = \frac{2\pi}{\lambda} = \frac{2\pi f}{c} \simeq 209.4$$

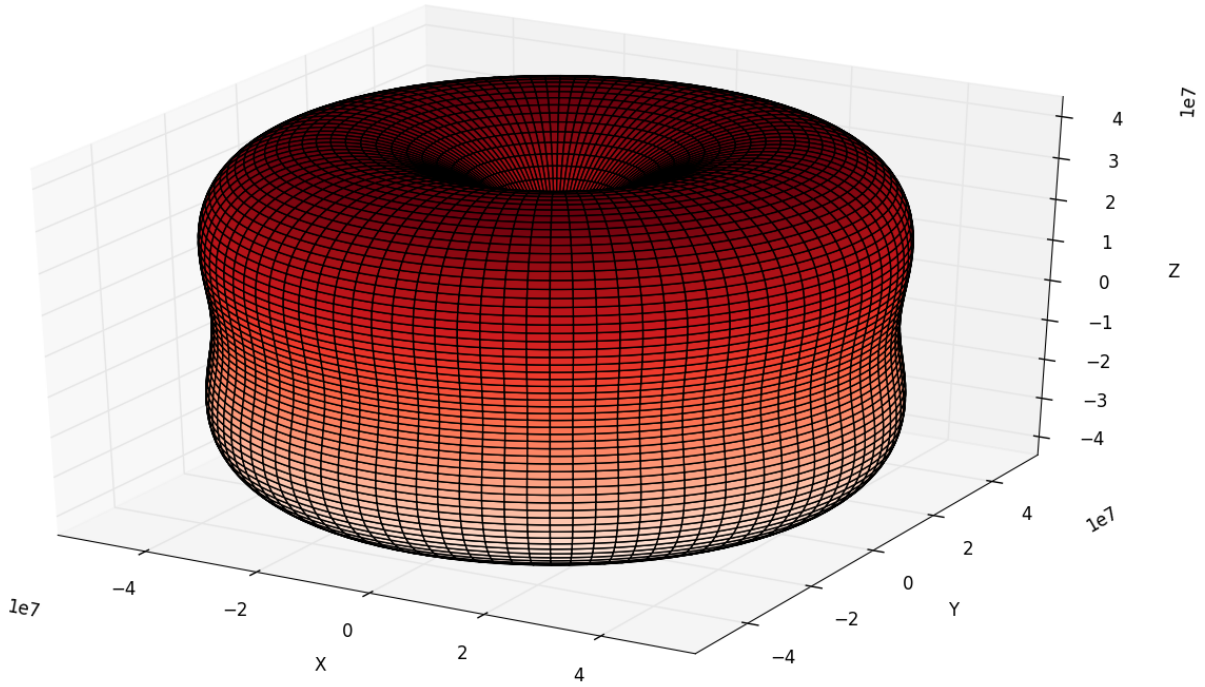
$$\text{so } r = 0.000477m$$

Patten of Near-Field Region



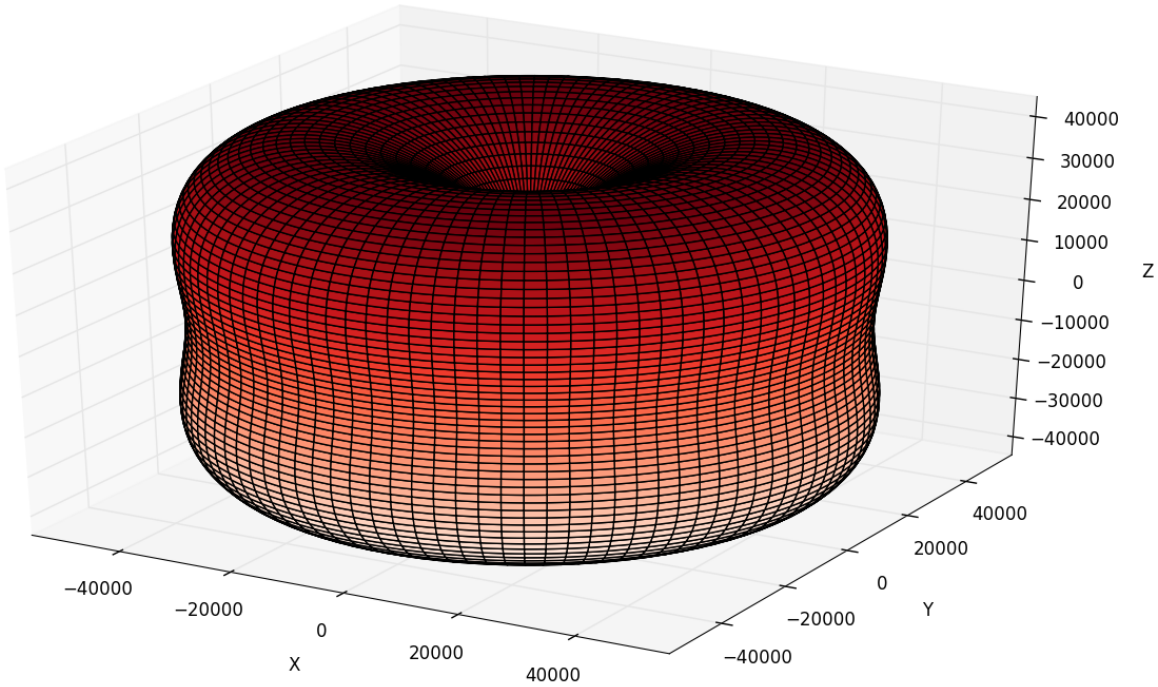
kr=0.01

Patten of Near-Field Region



kr=0.1

Patten of Near-Field Region

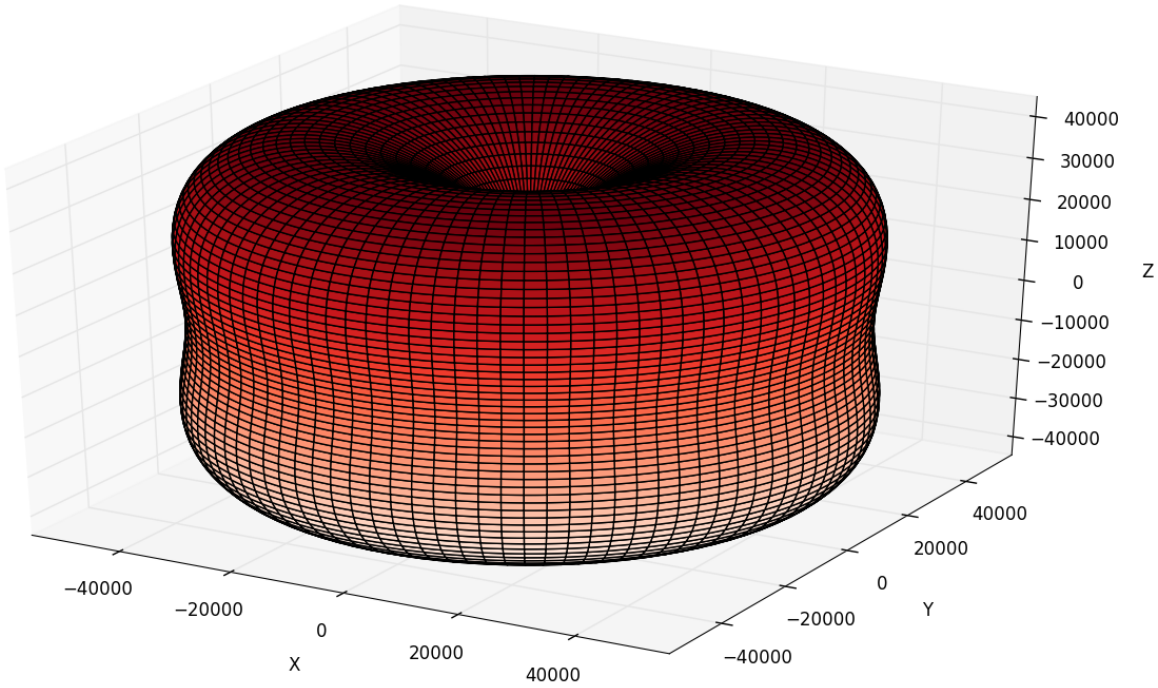


kr=1

Patten of Intermediate-Field Region

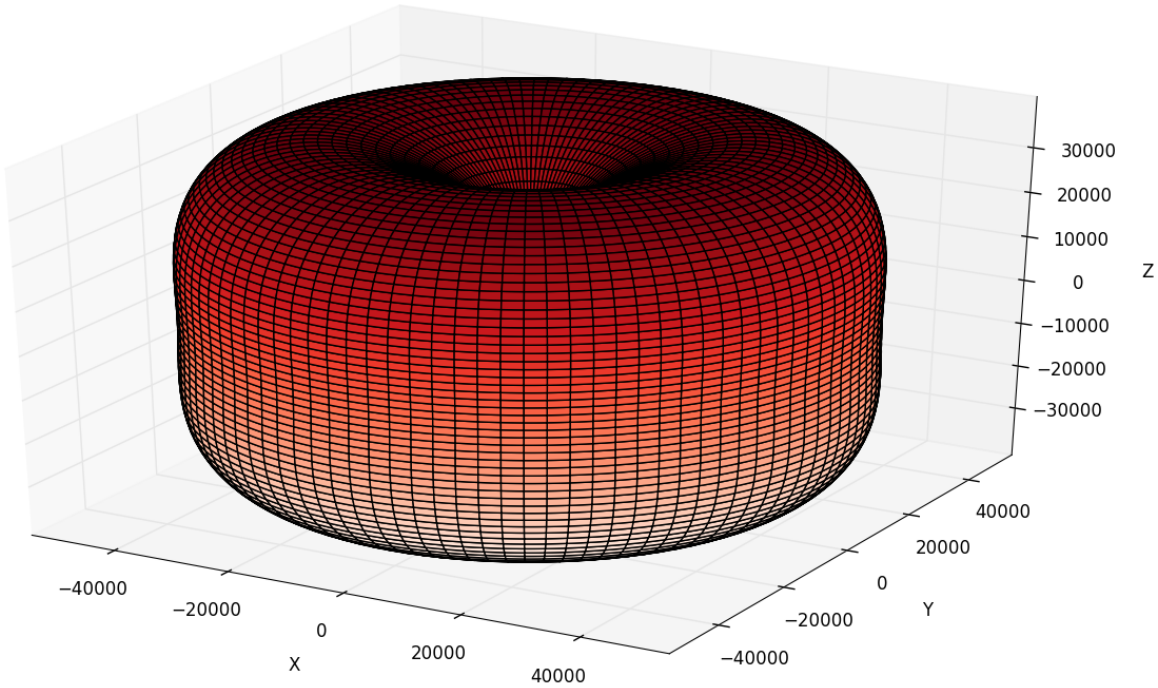
$$\left.\begin{aligned} E_r &\simeq \eta \frac{I_0 l e^{-jkr}}{1\pi r^1} \cos\theta \\ E_\theta &\simeq j\eta \frac{k I_0 l e^{-jkr}}{4\pi r} \sin\theta \\ E_\phi &= H_r = H_\theta = 0 \\ H_\phi &\simeq j \frac{k I_0 l e^{-jkr}}{4\pi r} \sin\theta \end{aligned}\right\} kr > 1 \qquad (2)$$

Patten of Intermediate-Field Region



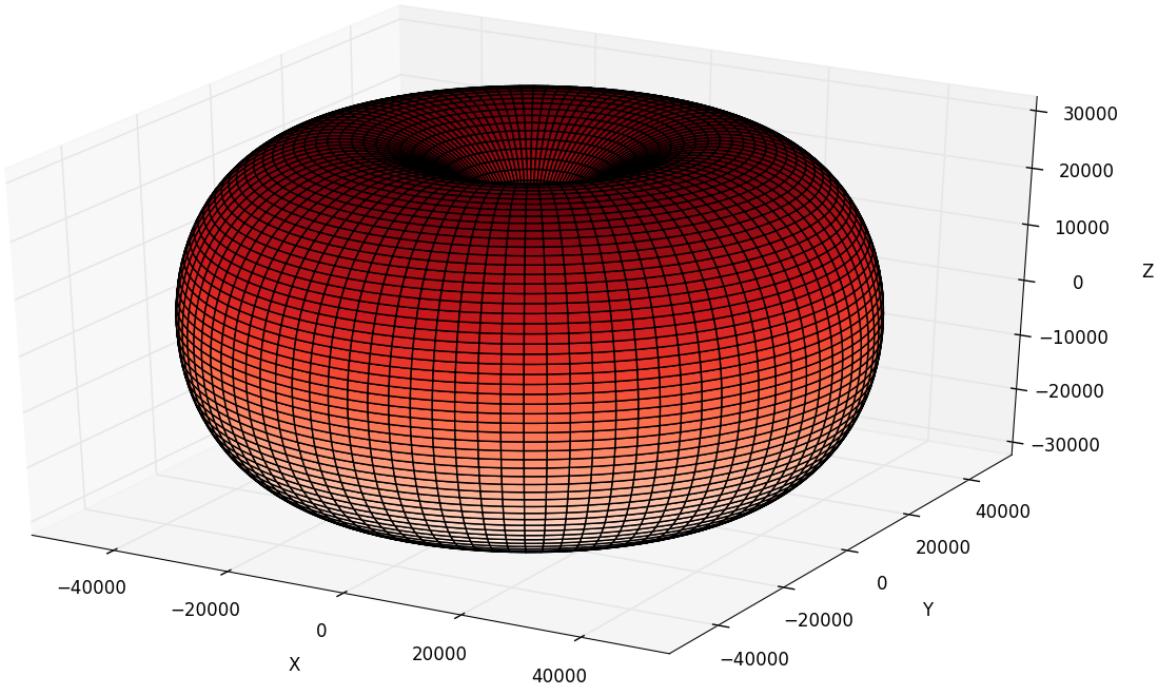
kr=1

Patten of Intermediate-Field Region



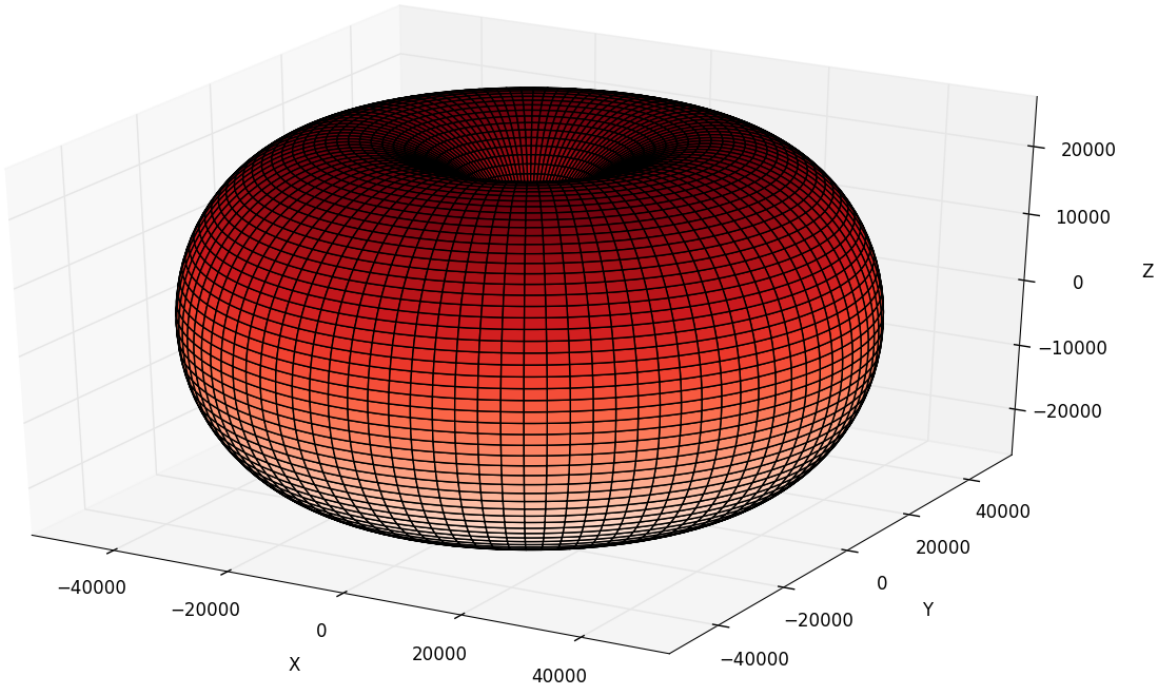
kr=1.1

Patten of Intermediate-Field Region



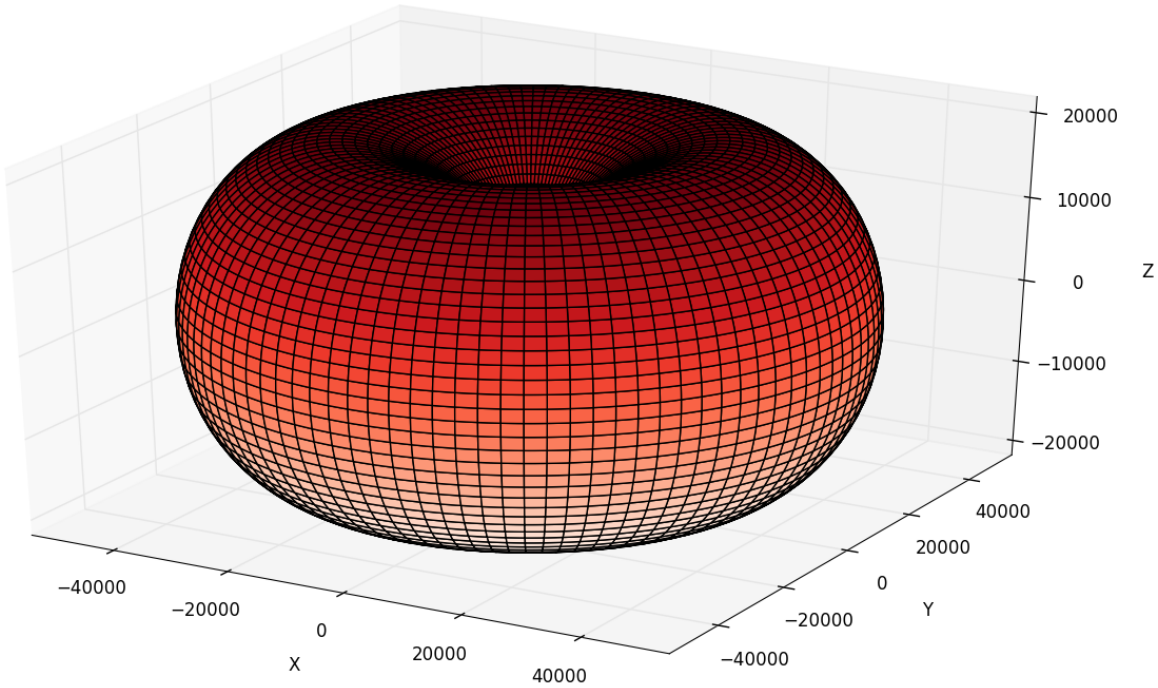
kr=1.5

Patten of Intermediate-Field Region



kr=2

Patten of Intermediate-Field Region

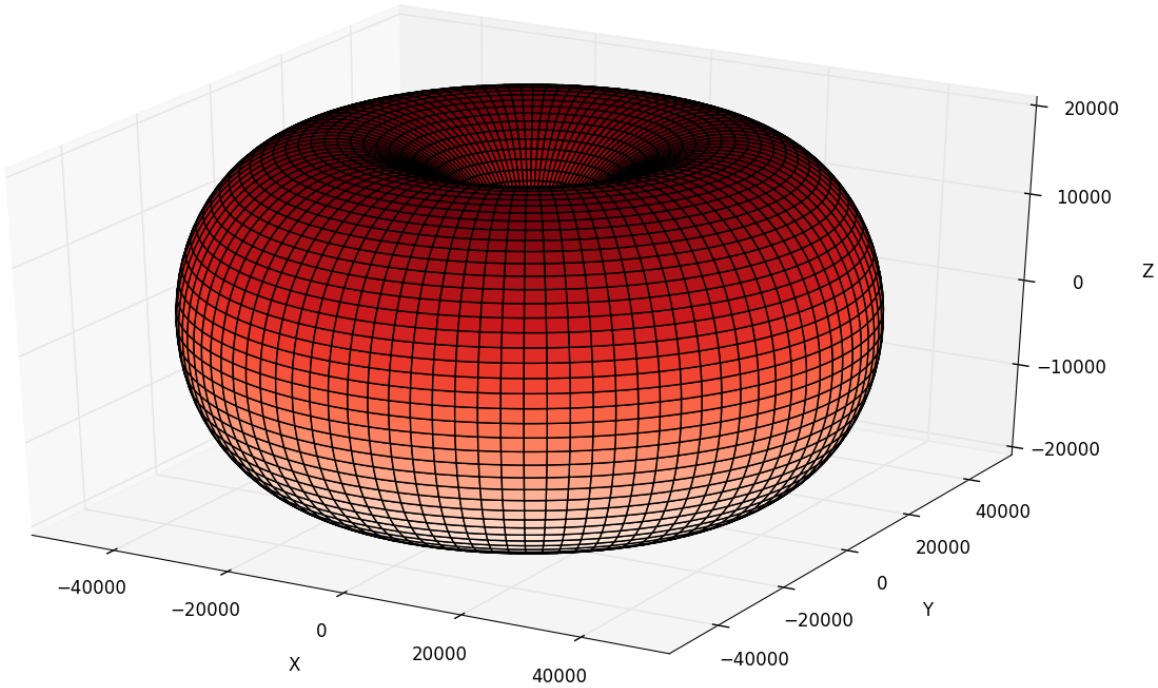


kr=5

Far-Field Region

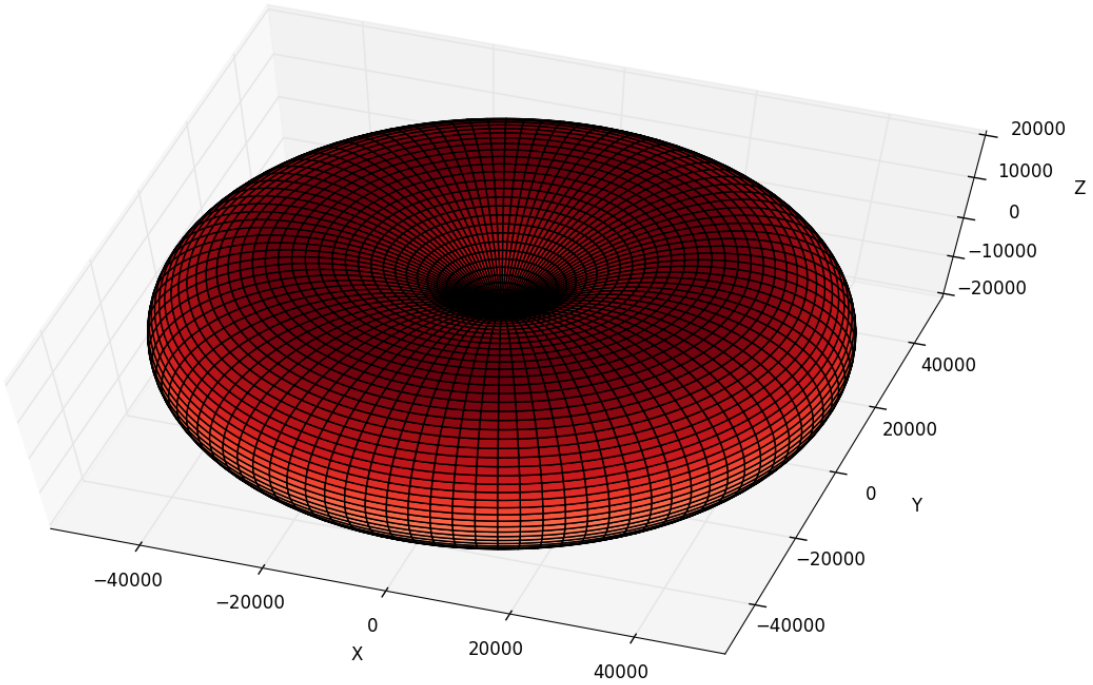
$$\left.\begin{aligned} E_\theta &\simeq j\eta k \frac{I_0 l e^{-jkr}}{4\pi r}\sin\theta \\ E_r = E_\phi &= H_r = H_\theta = 0 \\ H_\phi &\simeq j\frac{k I_0 l e^{-jkr}}{4\pi r}\sin\theta \end{aligned}\right\} kr \gg 1 \tag{3}$$

Patten of Far-Field Region



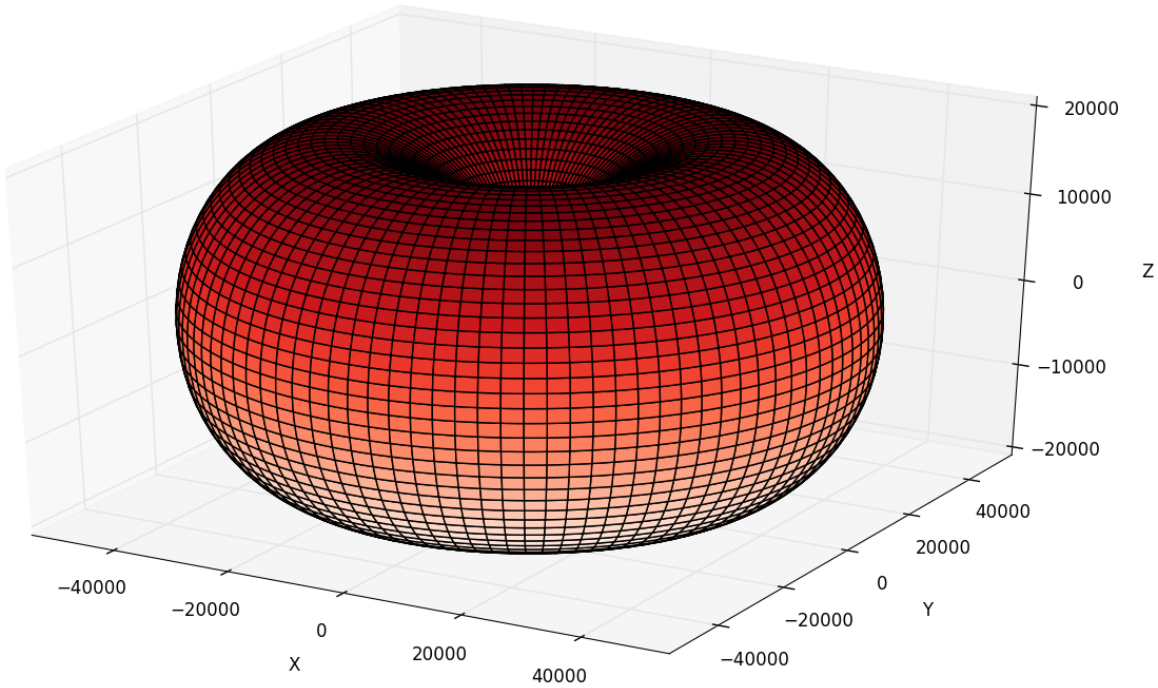
kr=10

Patten of Far-Field Region



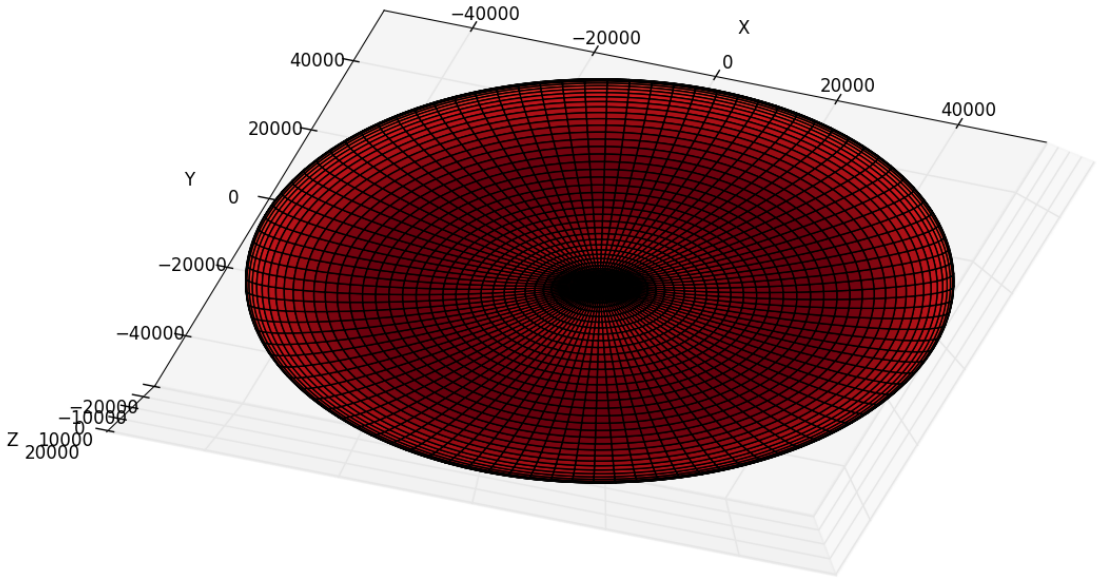
kr=10

Patten of Far-Field Region



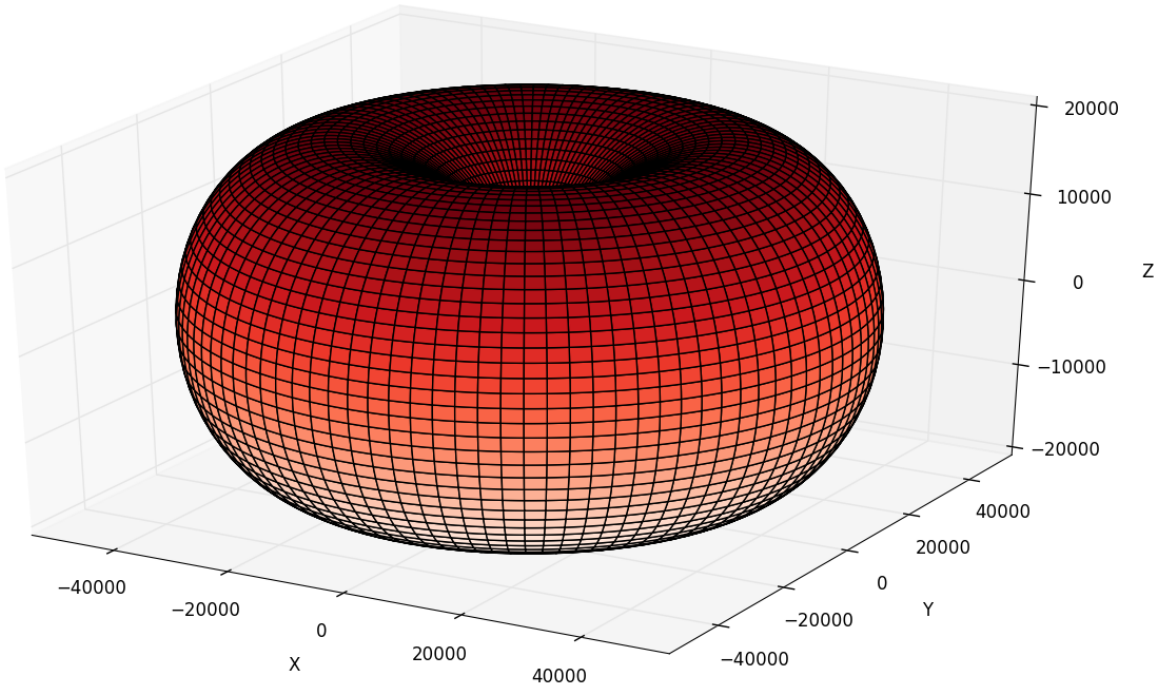
kr=100

Patten of Far-Field Region



kr=100

Patten of Far-Field Region

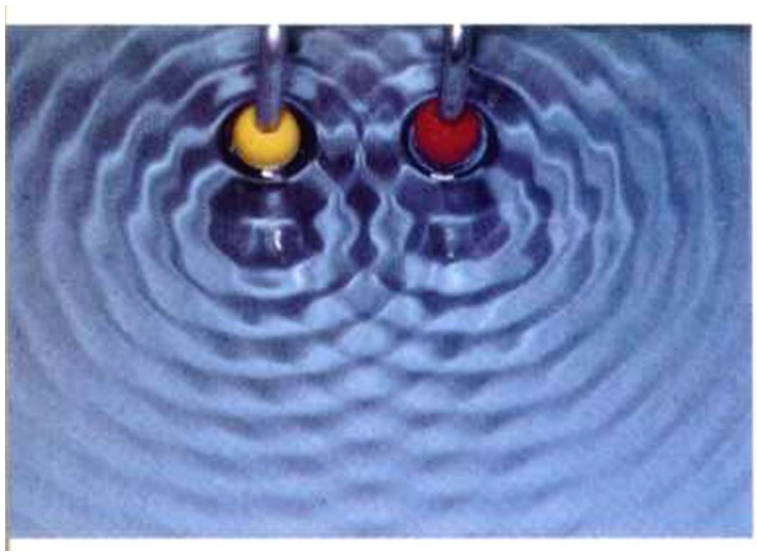


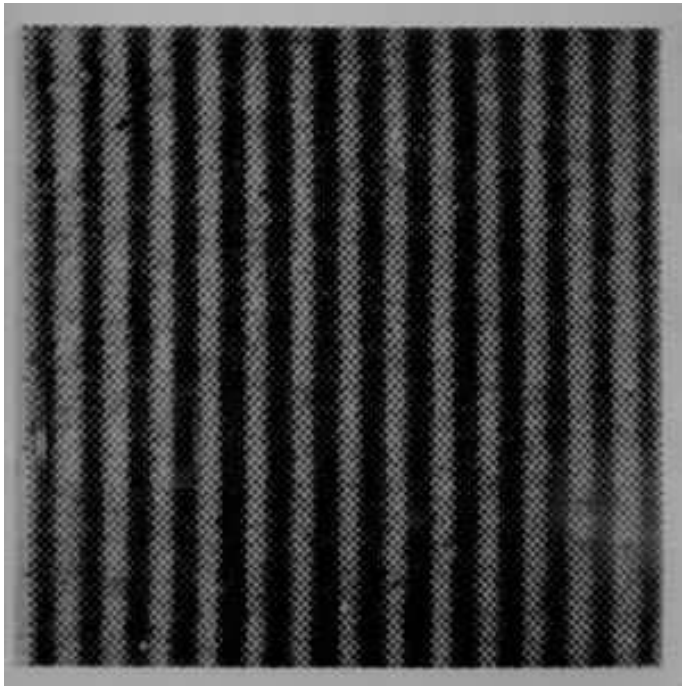
kr=10000

flapdoodle

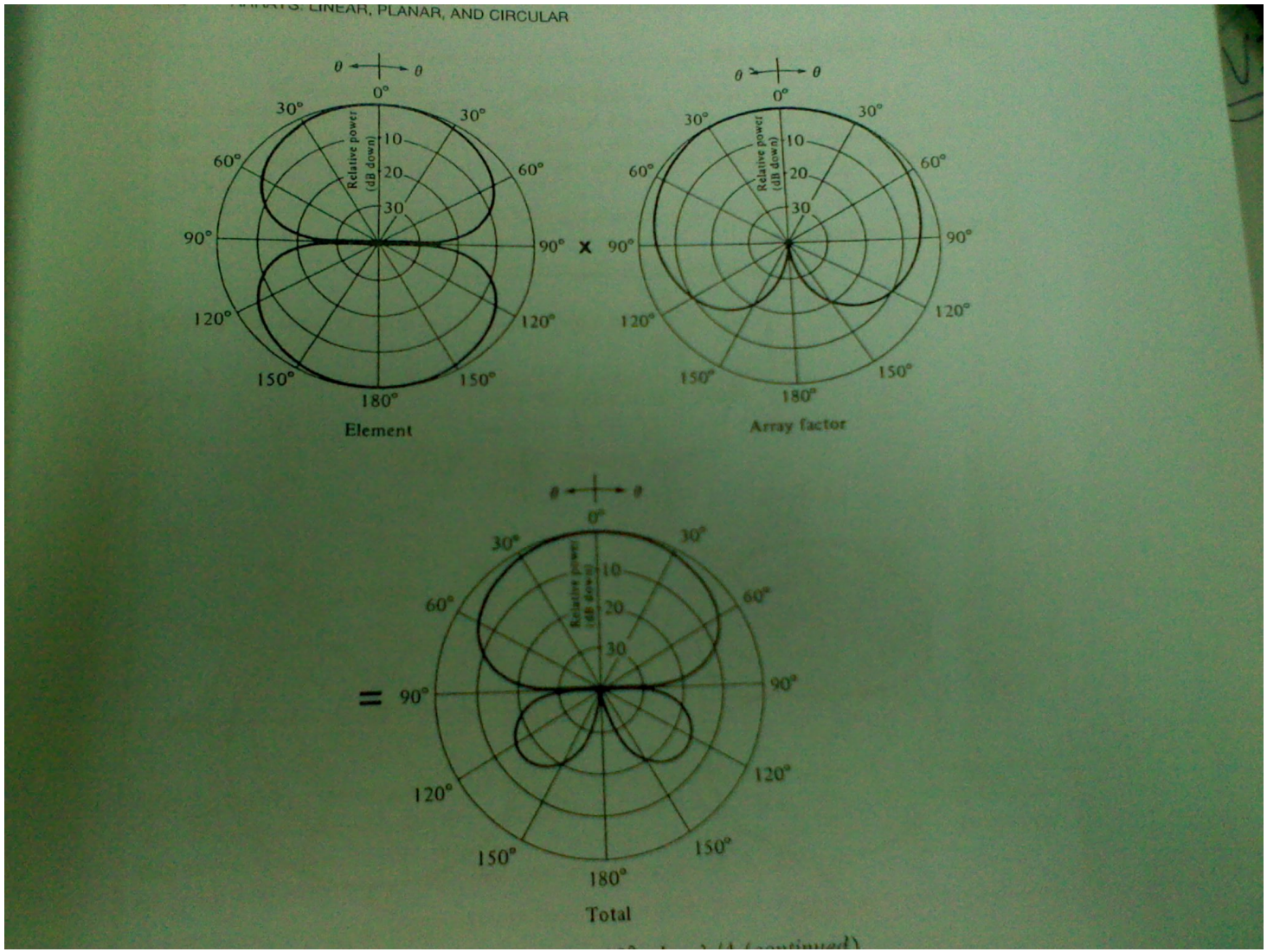
Sidelobe

Interference $\Rightarrow$ *Sidelobe*





Array Factor



Fourier transform

A

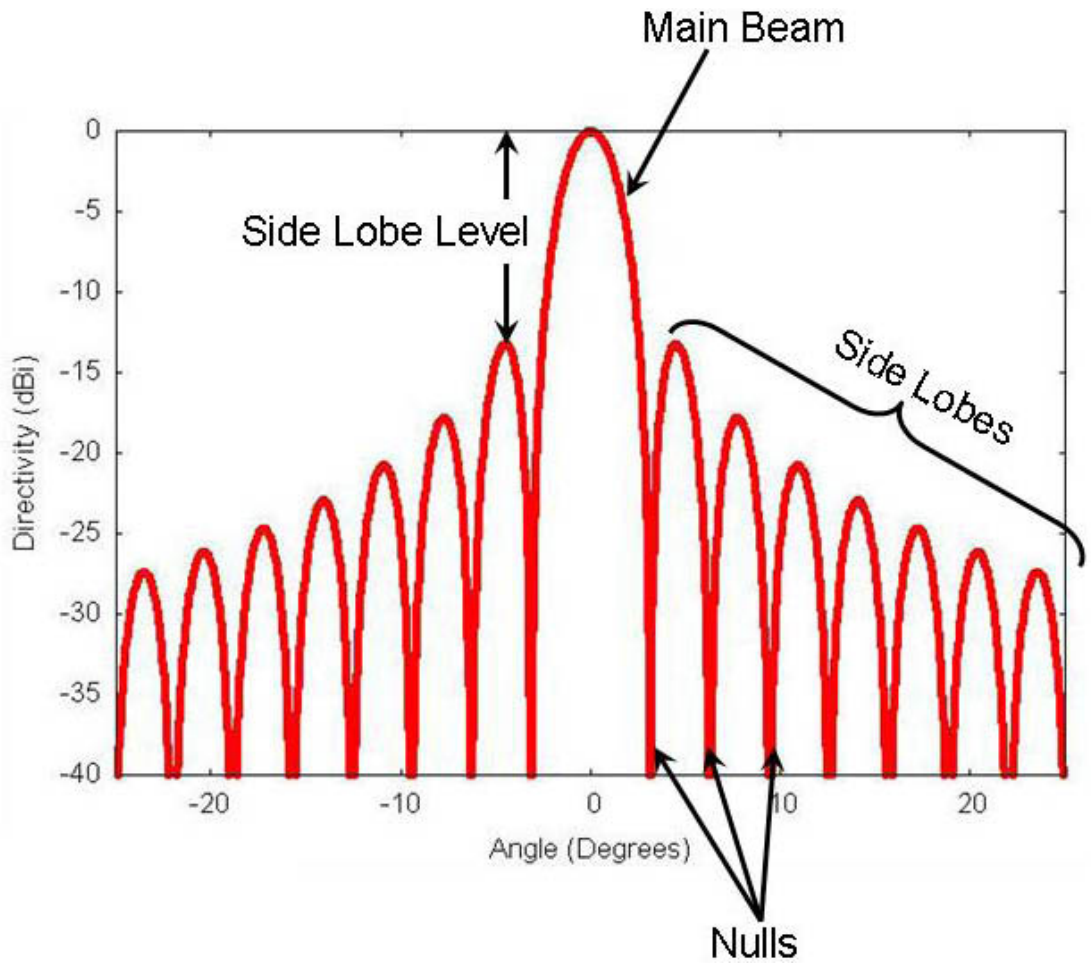
$$\mathbf{A}(x,y,z) = \frac{\mu}{4\pi}\int_C \mathbf{I}_e(x',y',z')\frac{e^{-jkR}}{R}dl'$$

$$R \simeq r - z'\cos\theta$$

E_θ

$$E_\theta = \int_{-l/2}^{+l/2} dE_\theta = j\eta\frac{ke^{-jkr}}{4\pi r}\sin\theta[\int_{-l/2}^{+l/2} I_e(x',y',z')e^{jkz'\cos\theta}dz']$$

$$Radiation\ Pattern(in\ units\ of\ dB) \propto 10log_{10}(|\frac{\sin X}{X}|)$$



a rectangular aperture antenna radiation pattern


Thank
You!