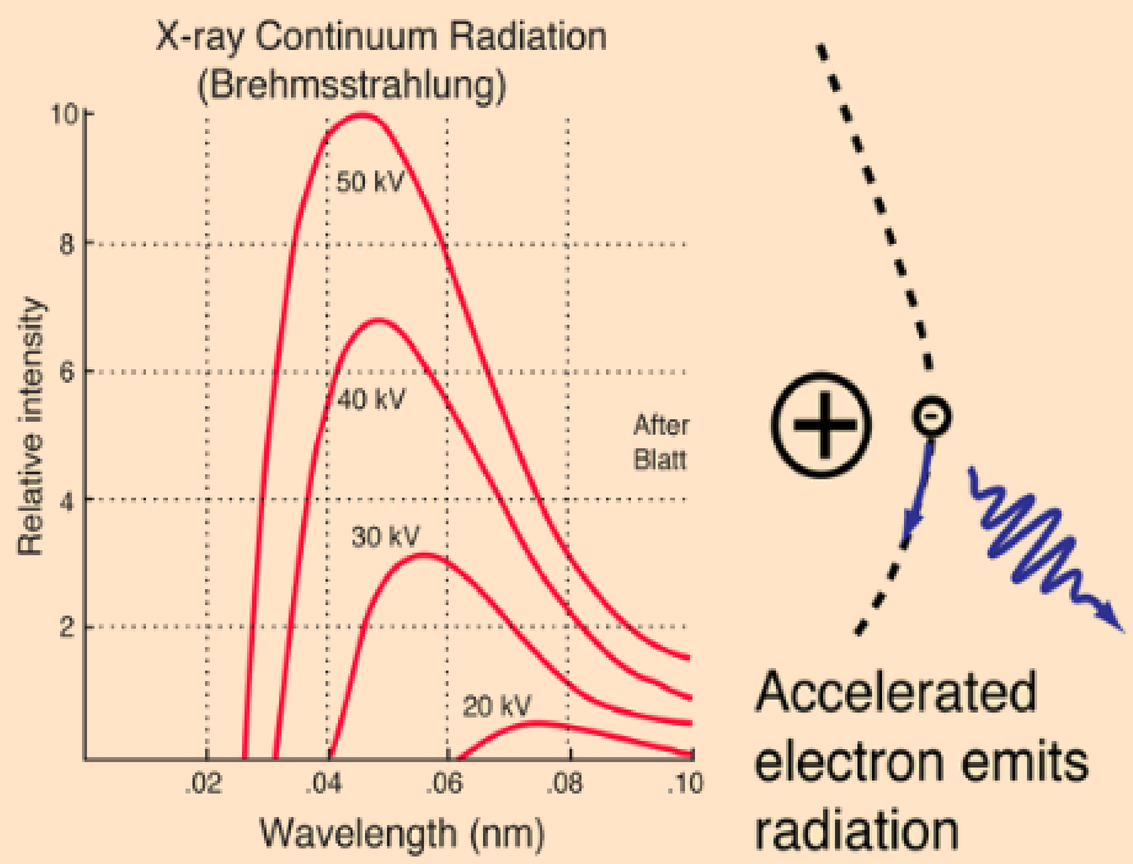
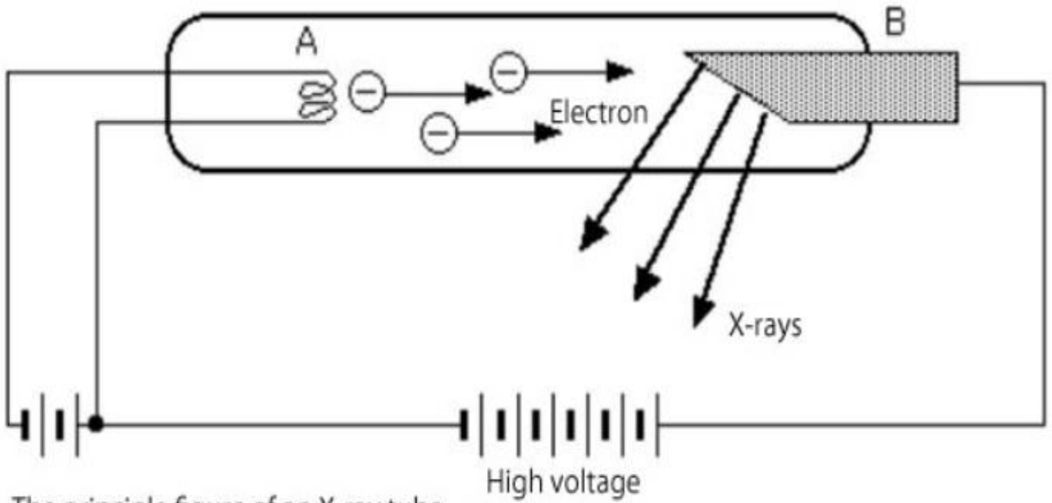
White x-ray formation



"Bremsstrahlung" means "braking radiation" and is retained from the original German to describe the radiation which is emitted when electrons are decelerated or "braked" when they are fired at a metal target. Accelerated charges give off electromagnetic radiation, and when the energy of the bombarding electrons is high enough, that radiation is in the x-ray region of the electromagnetic spectrum. It is characterized by a continuous distribution of radiation which becomes more intense and shifts toward higher frequencies when the energy of the bombarding electrons is increased

X- Ray Machin



The principle figure of an X-ray tube
A Tungsten filament
B Cathode metal

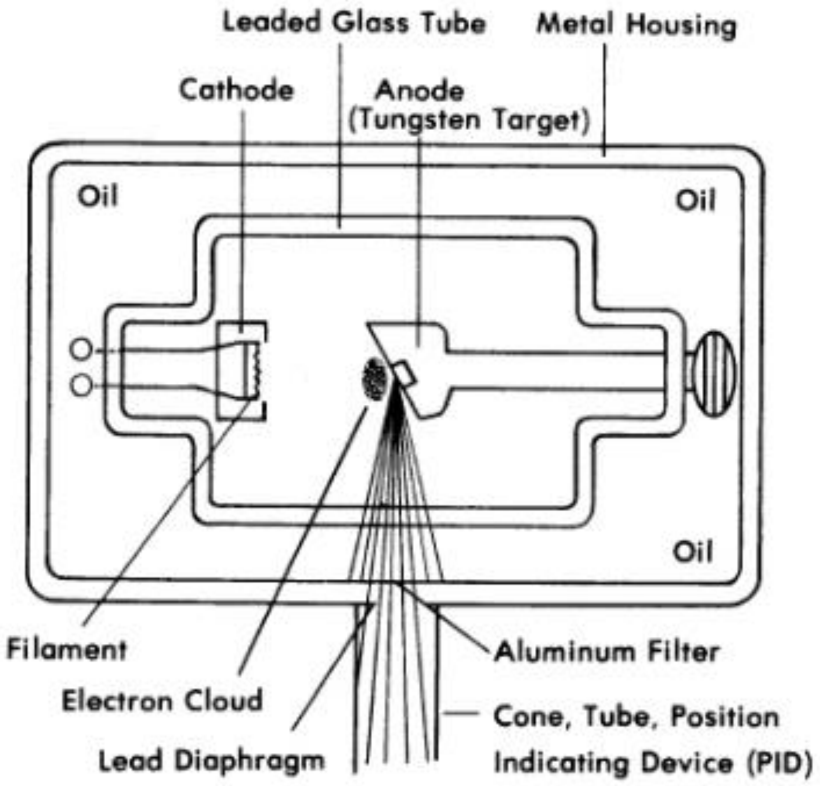
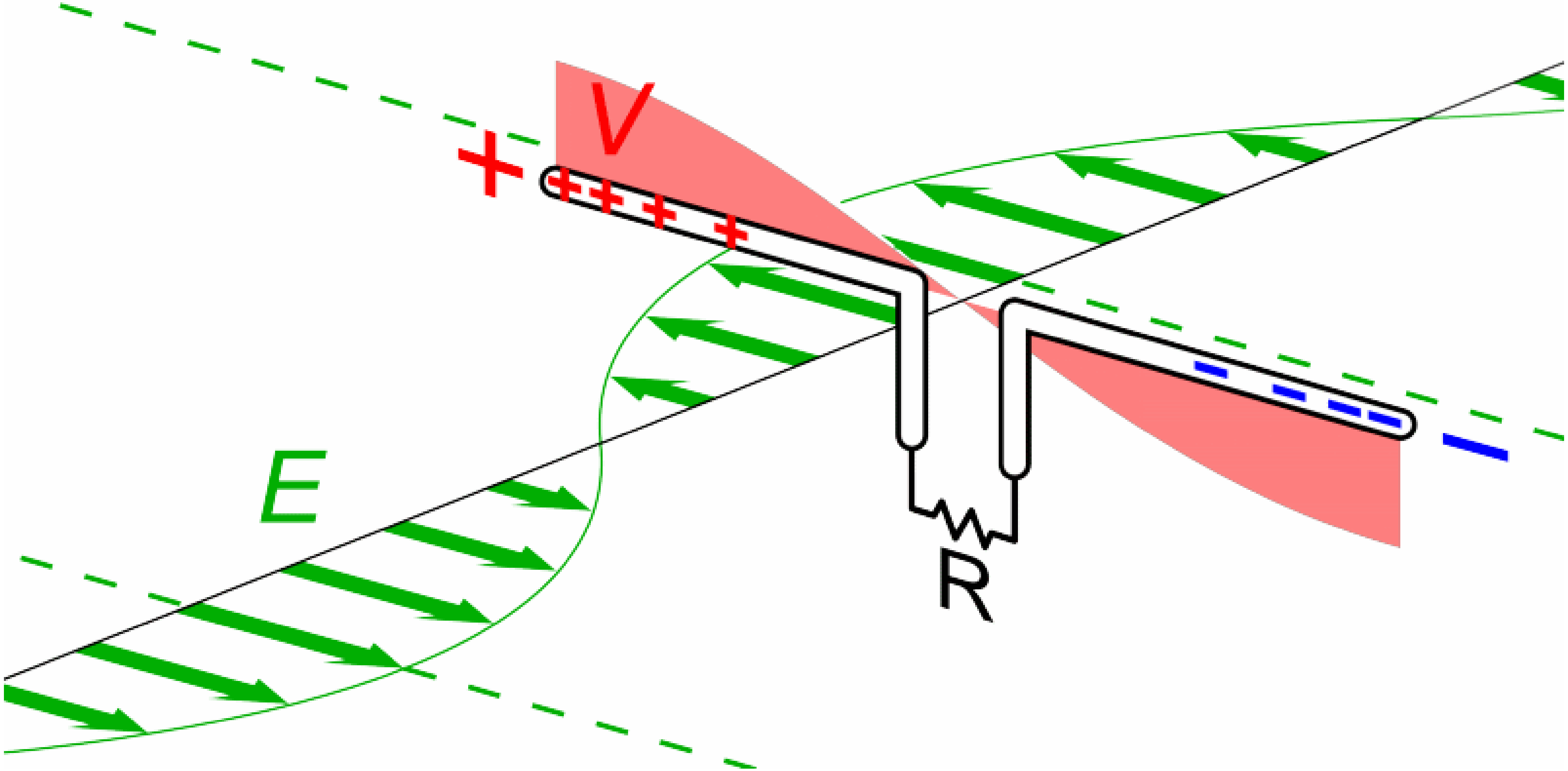


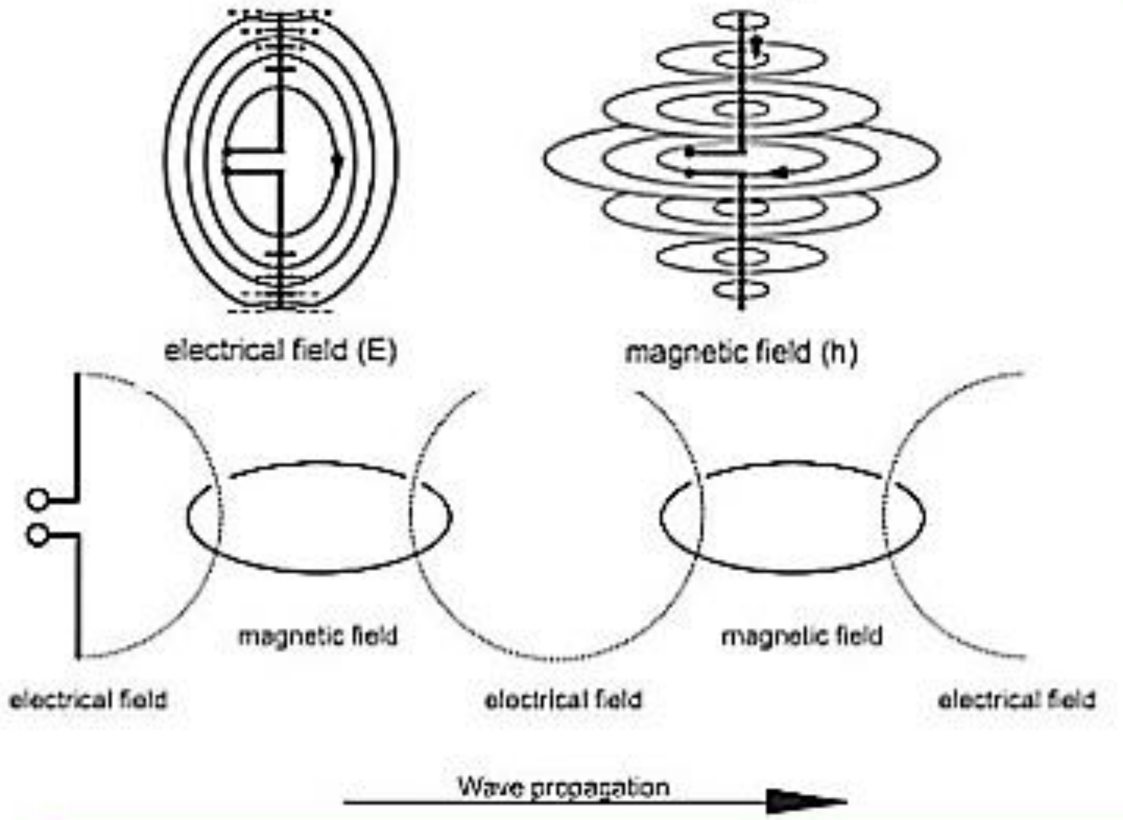
Figure 1-5. Electrons striking the anode (tungsten target) producing x-ray photons.

Formation of electromagnetic wave by antaea



How wave propagates ?

Using Dipole antenna as an example



Understand this :

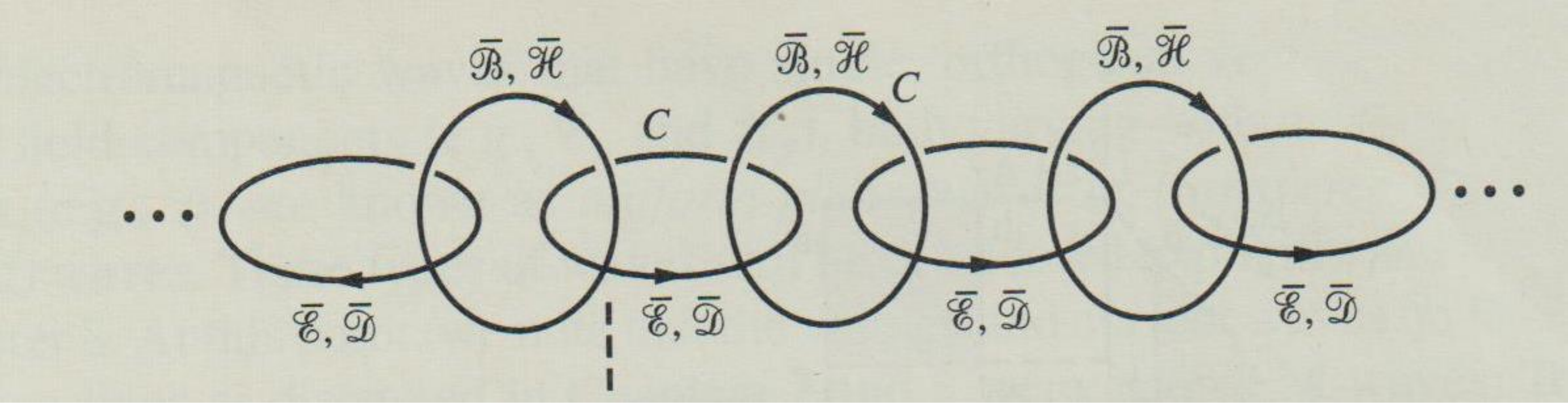
- Electric field will produce magnetic field
- **Changing** in magnetic field will produce electric field

This process rotate continuously , thus creating waves.

It is appears that if we start with a magnetic field at one point in space and change it with time, Maxwell's equations dictate that magnetic fields and electric fields are created at surrounding points, where there are NO free charges and/or free currents, i.e. $q = J = 0$, as follows:

$$\nabla \times \overline{E} = -\frac{\partial \overline{B}}{\partial t} \qquad\qquad \nabla \times \overline{B} = \mu_0 \varepsilon_0 \frac{\partial \overline{E}}{\partial t}$$

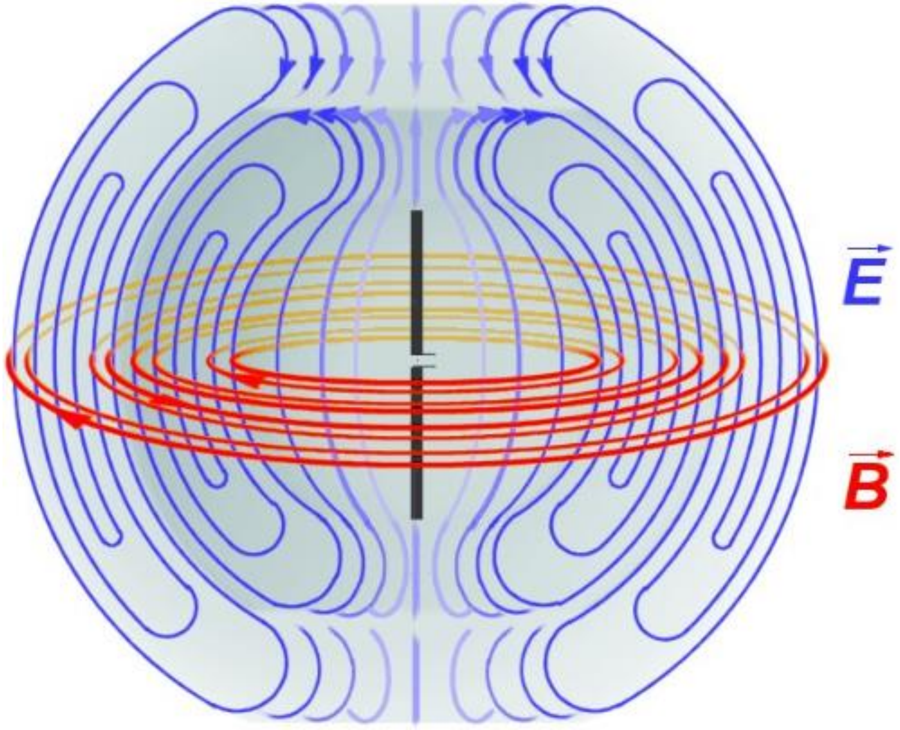
– that is to say that the disturbance initiated by the changing magnetic field propagates away from its point of origin, indicated by the dashed line in the Figure below.

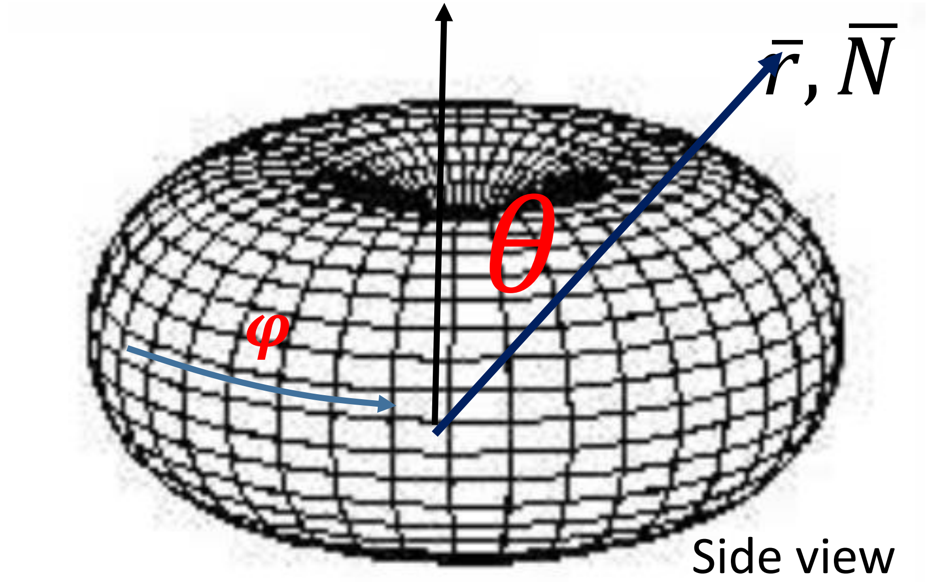


origin

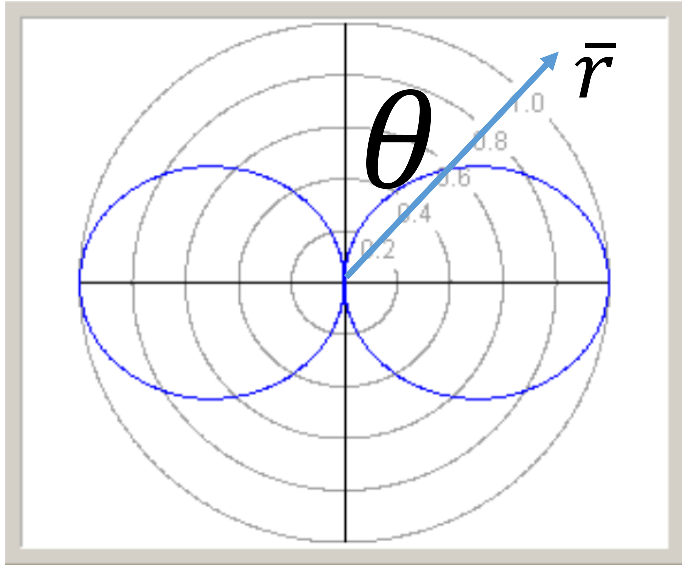
Intensity distribution of linear antenna:

$Its\ vector\ poynting\ [N]\ \propto N_0 sin^2\theta$, independent of $\varphi, resulting\ doughnut - shaped\ pattern$.





Cross section

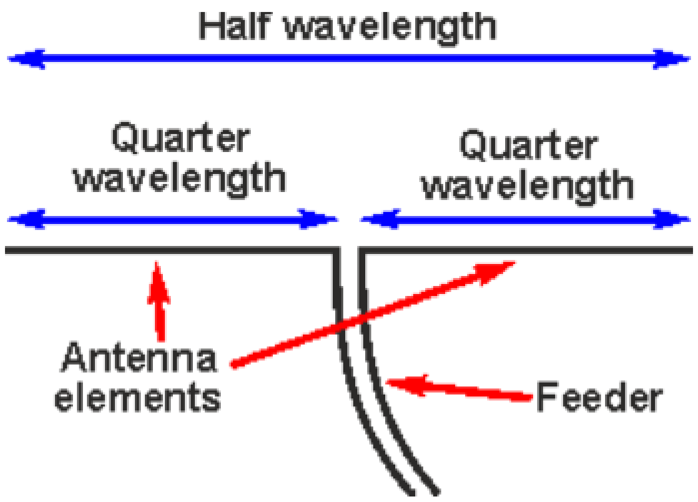


Emitter/receiver

Dynamic simulations

half wave dipole and directivity .

The half wave dipole is the most widely used version of the dipole antenna or aerial. The antenna is **half wavelength long**, the shortest resonant length that can be used for a resonant dipole.

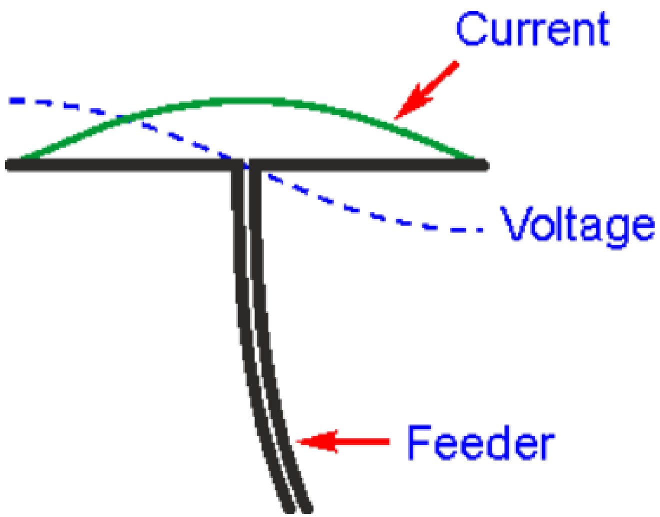


Half wave dipole antenna

It is typically fed in its center where the impedance falls to its lowest. In this way, the antenna consists of the feeder connected to two quarter wavelength elements in line with each other.

The voltage and current levels vary along the length of the radiating section of the antenna. This occurs because standing waves are set up along the length of the radiating element.

At the ends of the antenna the current is zero and hence the voltage maximum. At the center, $\frac{\lambda}{4}$ from its ends, the current is maximal and the voltage is minimal.
The radiant power in any direction can be obtained by treating the whole dipole as a sett of Hertzian dipoles, each has a different distance to any point in space.



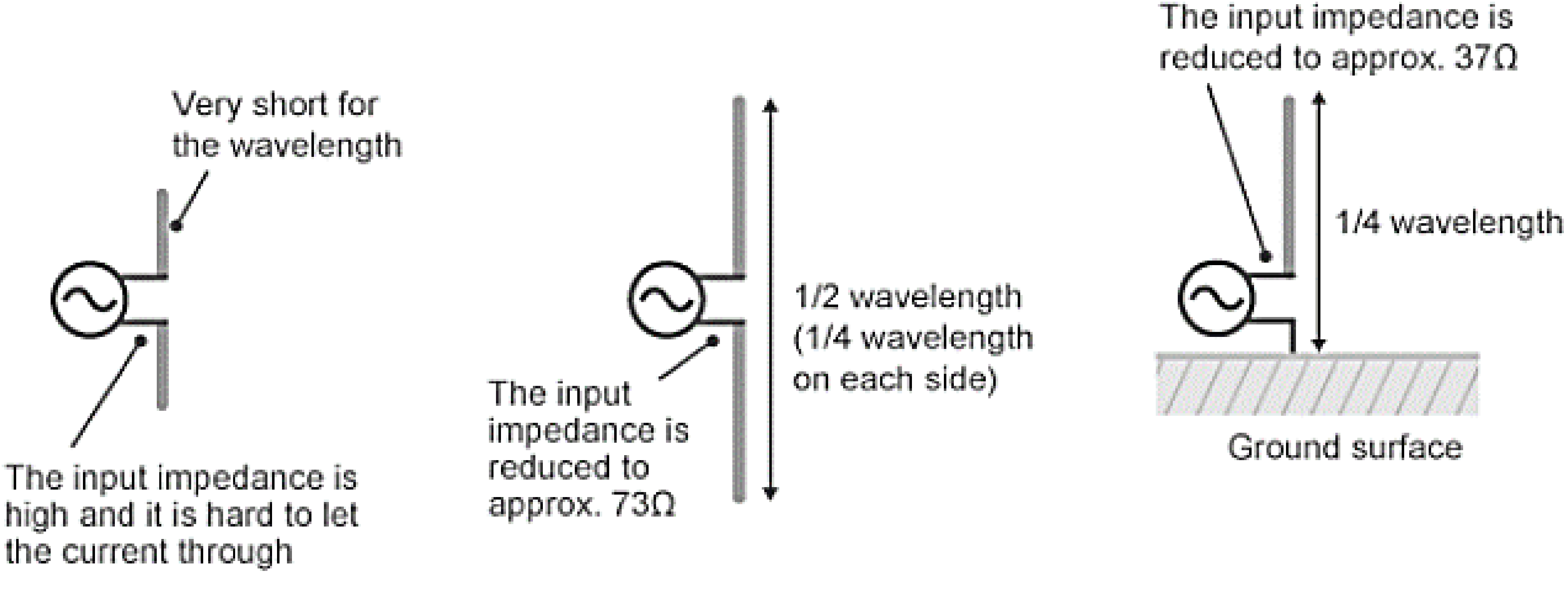
$A\ {}^{\lambda}/_{2}$ dipole is efficient radiator than Hertzian dipole since its radiation resistance is $\sim 73\Omega$, providing a better match to connecting cables, which usually have a characteristic impedance of about 75Ω.

Antenna radiation resistance/impedance

The mean power $\langle P \rangle$ radiated from an ocilating Hertzian dipole, in analogy to a resistor, can be expressed as $I^2 R$ where R here the radiation resistance R_{rad} of the source.

$$\langle P \rangle = R_{rad} I^2 = \frac{2\pi}{2\varepsilon_0 c}\left(\frac{dl}{\lambda}\right)^2 I^2 \quad \rightarrow R_{rad} \sim 800\left(\frac{dl}{\lambda}\right)^2 \Omega$$

Hence, for instance, a dipole with $\frac{dl}{\lambda} = 0.01\ has\ R_{rad} \approx\ 0.08\ \Omega$



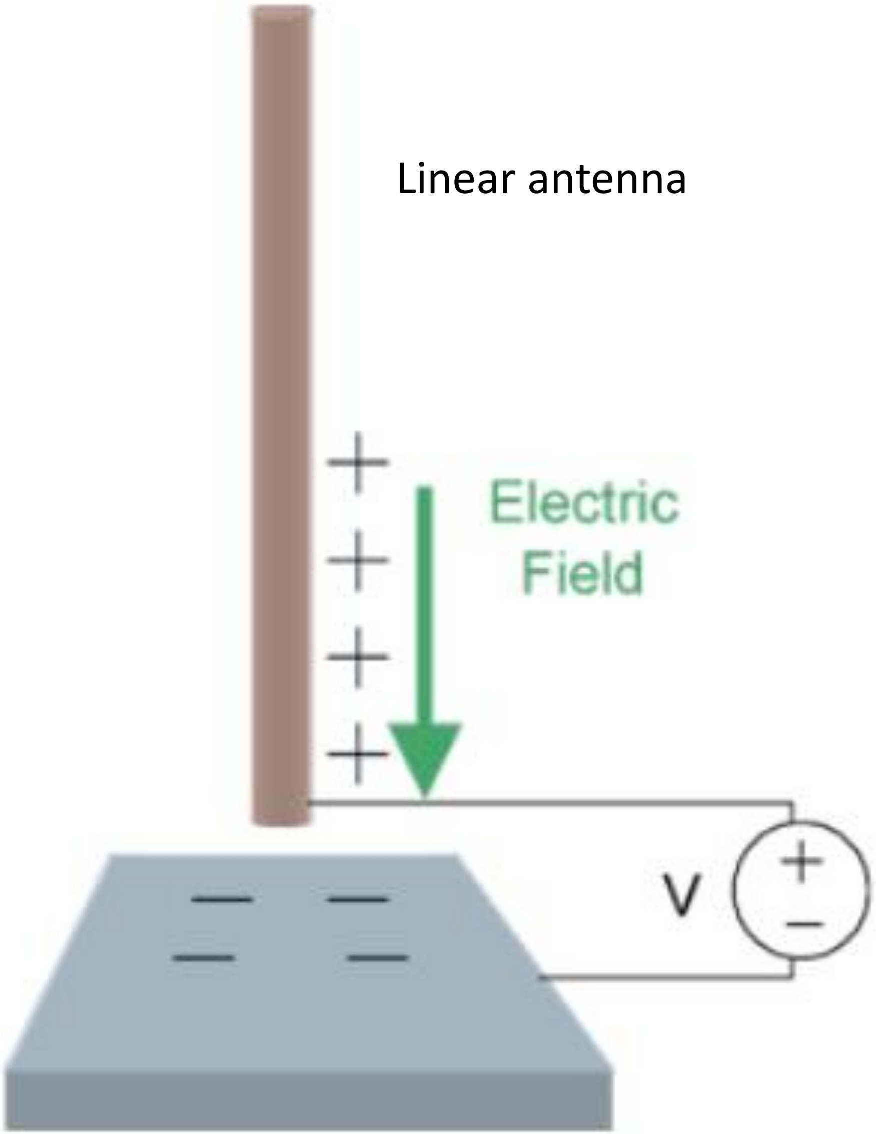
(a) Short dipole antenna

(b) 1/2 wavelength dipole antenna

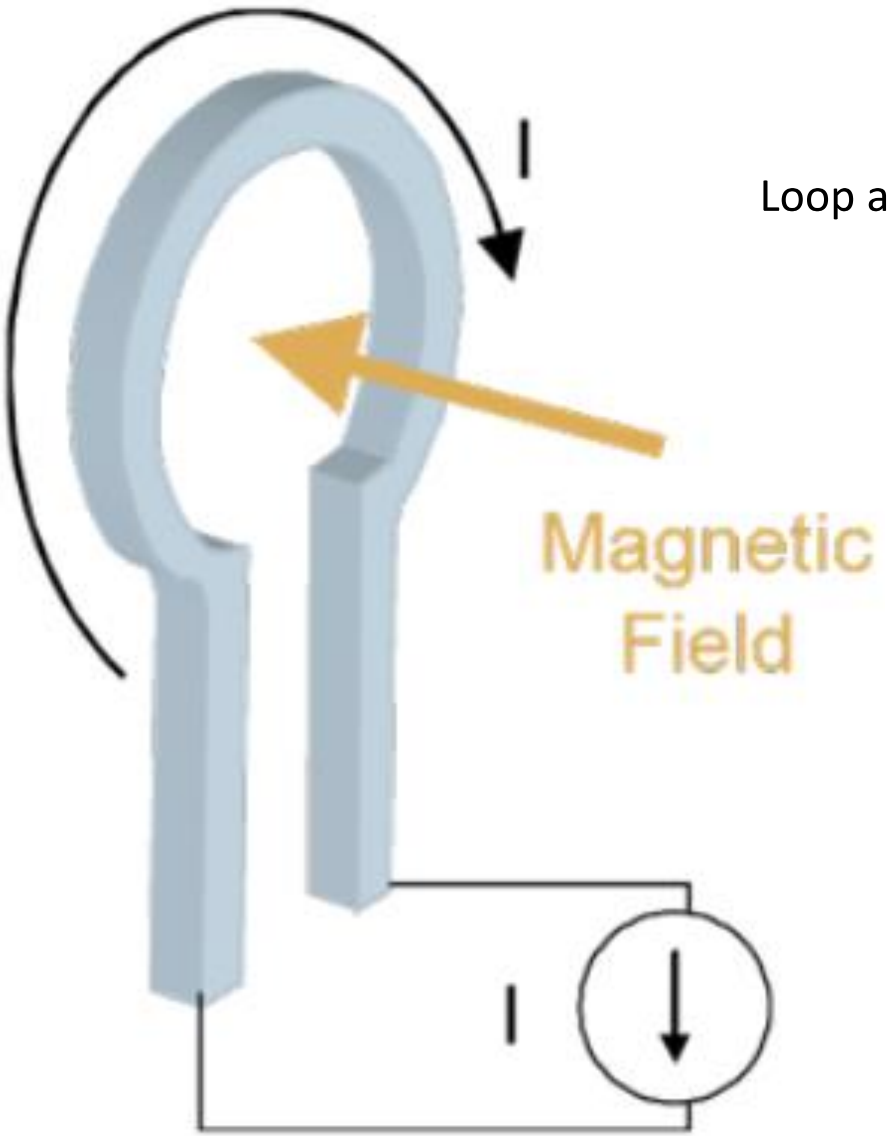
(c) 1/4 wavelength monopole antenna

Earth can be used as a mirror

Linear antenna

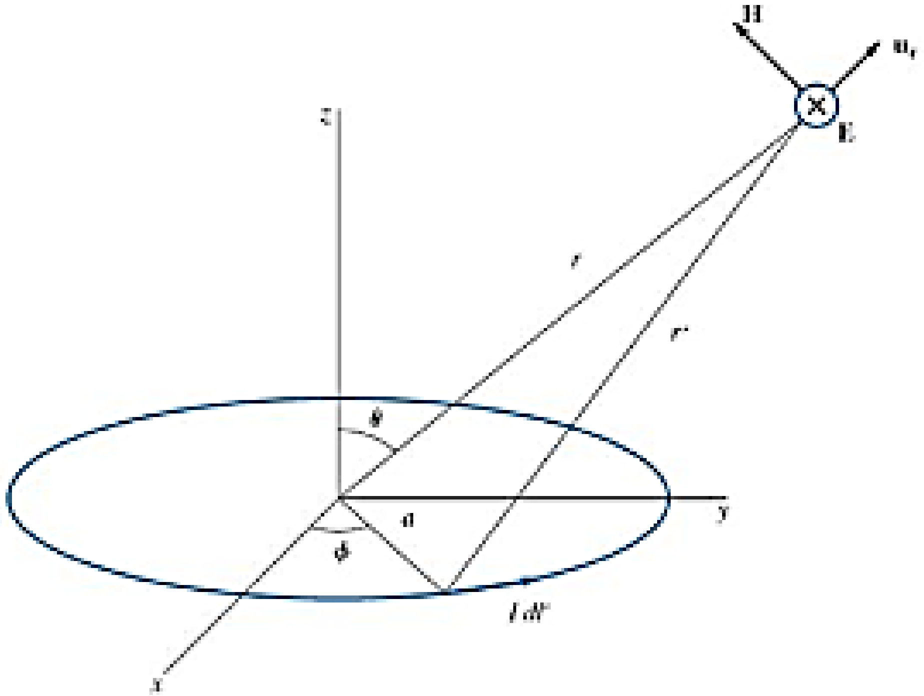


Loop antenna



Loop antenna

A loop antenna consists of a small conductive loop with a current circulating through it.



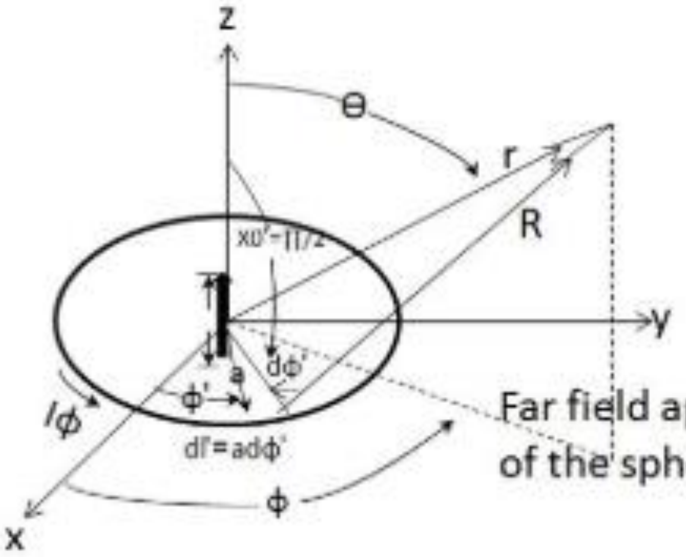
We have previously discussed that a loop carrying a current can generate a magnetic dipole moment. Thus, we may consider this antenna as equivalent to a magnetic dipole antenna.

If the loops circumference $C < \lambda/10$
The antenna is called electrically small. If C is in order of λ or larger, the antenna is electrically large. Commonly, these antennas are used in a frequency band from about 3 MHz to about 3 GHz. Another application of loop antennas is in magnetic field probes.

Loop Radiation

A small loop antenna (ka<<1) can be considered as a matching twin to the dipole antenna with the electric and magnetic fields characteristics exchanged. In other words we can consider the radiation from a loop antenna as equivalent to that from a magnetic dipole.

Accordingly, for **harmonic time dependence** of the signal, the electric and magnetic fields of a **small loop** antenna can be described by



$$\underline{E}(x,y,z,t) = \Re e\left\{E(x,y,z)e^{j\omega t}\right\}$$

$$\underline{E} = -j\omega\mu\left(\pi a^2 I_0\right)\left[jk + \frac{1}{r}\right]\frac{e^{-jkr}}{4\pi r}\sin\theta\,\hat{x}_\phi \quad ; \quad k = \frac{2\pi}{\lambda} = \omega\sqrt{\mu\varepsilon}$$

$$\underline{H} = \left(\pi a^2 I_0\right)\left[\frac{jk}{r} + \frac{1}{r^2}\right]\frac{e^{-jkr}}{2\pi r}\cos\theta\,\hat{x}_r + \left(\pi a^2 I_0\right)\left[-k^2 + \frac{jk}{r} + \frac{1}{r^2}\right]\frac{e^{-jkr}}{4\pi r}\sin\theta\,\hat{x}_\theta$$

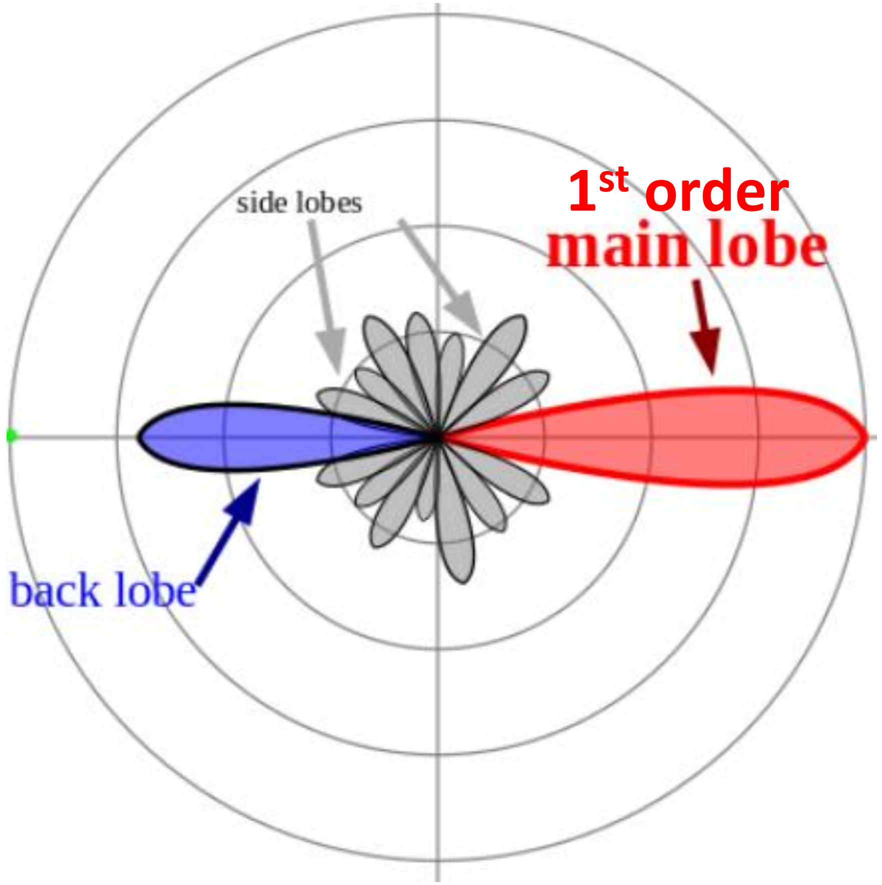
Far field approximation: $Max\left\{r \geq \frac{2D^2}{\lambda}, 5\lambda\right\}$ with D being the diameter of the sphere encircling the antenna

$$E_\phi \sim \left(\pi a^2 I_0\right)k^2\eta\frac{e^{-jkr}}{4\pi r}\sin\theta \quad ; \quad \eta = \sqrt{\frac{\mu}{\varepsilon}}$$

$$H_\theta \sim -\left(\pi a^2 I_0\right)k^2\frac{e^{-jkr}}{4\pi r}\sin\theta$$

Directivity: a fundamental **antenna** parameter. It is a measure of how 'directional' an **antenna's** radiation pattern is. An **antenna** that radiates equally in all directions would have effectively zero directionality, and the **directivity** of this type of **antenna** would be 1 (or 0 dB).

The greatest directivity is achieved by using a linear planar array of dipoles fed in certain phase relationships. For instance, a single line parallel vertical dipoles fed in phase behaves like a liner diffraction grating and produce an intense zero order beam perpendicular to the plane of the array.



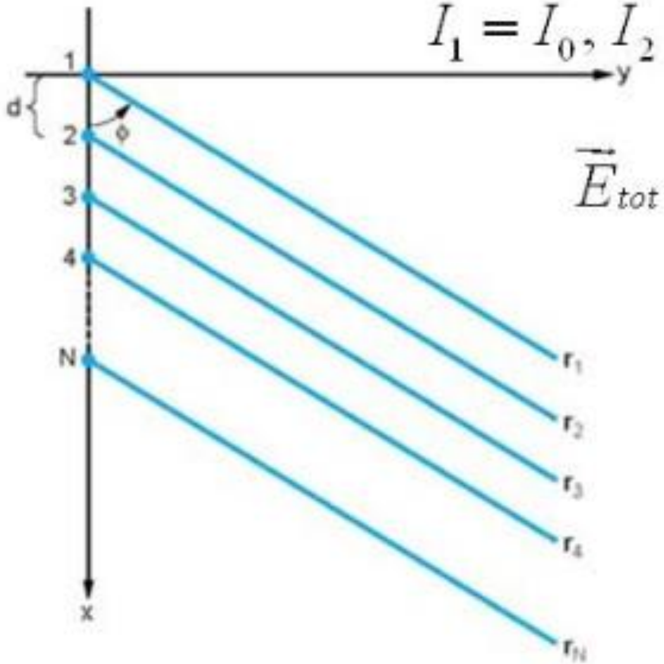
There cases where that concentrated radiation energy is undesired, e.g. when all-round broadcasting over- wide area is required.

Array directivity diagram

N-element linear arrays

We will simplify assumptions as follows:

1. The array is linear, evenly spaced along the line.
2. The array is uniform, driven by the same magnitude current source with constant phase difference between adjacent elements.

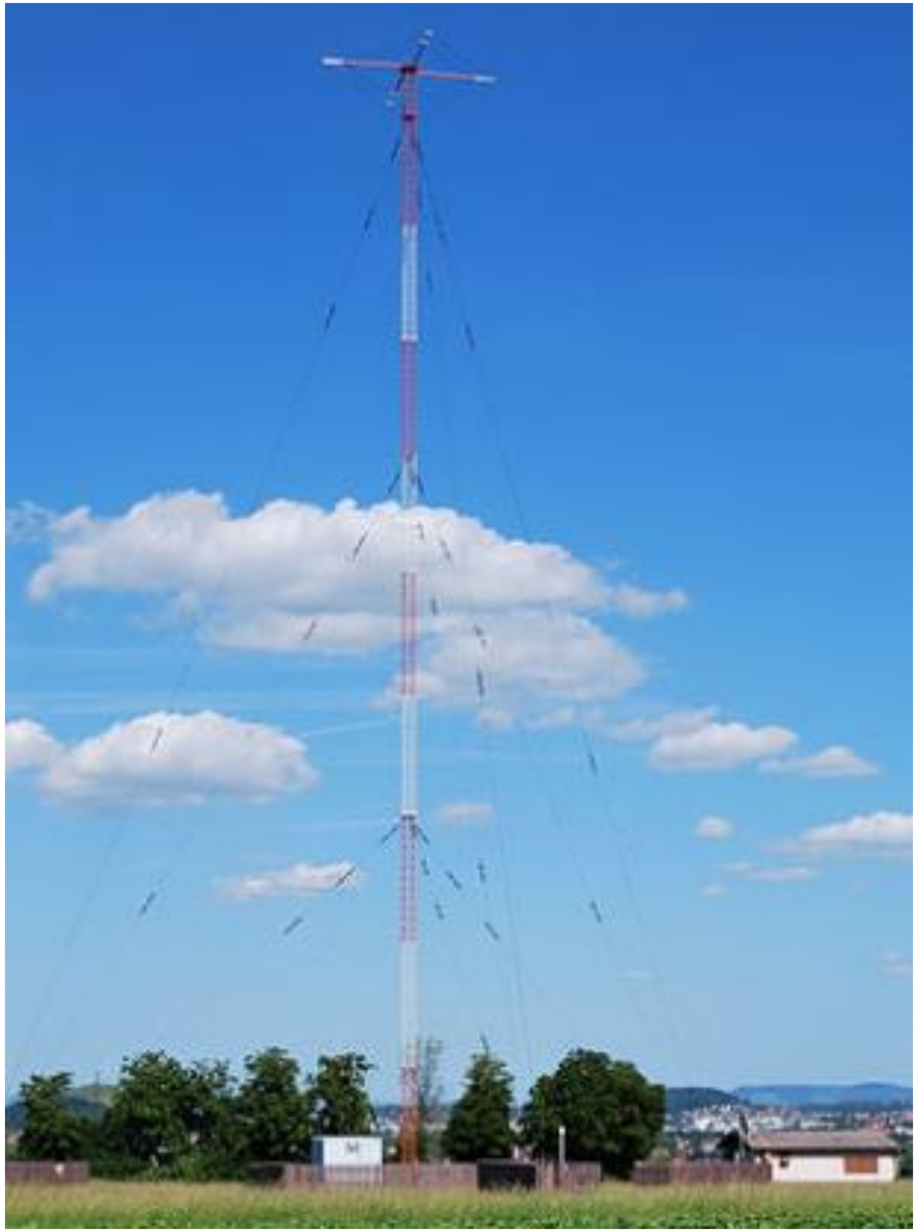


$$I_1 = I_0, I_2 = I_0 e^{j\alpha}, I_3 = I_0 e^{j2\alpha}, I_4 = I_0 e^{j3\alpha}, \ldots I_N = I_0 e^{j(N-1)\alpha}$$

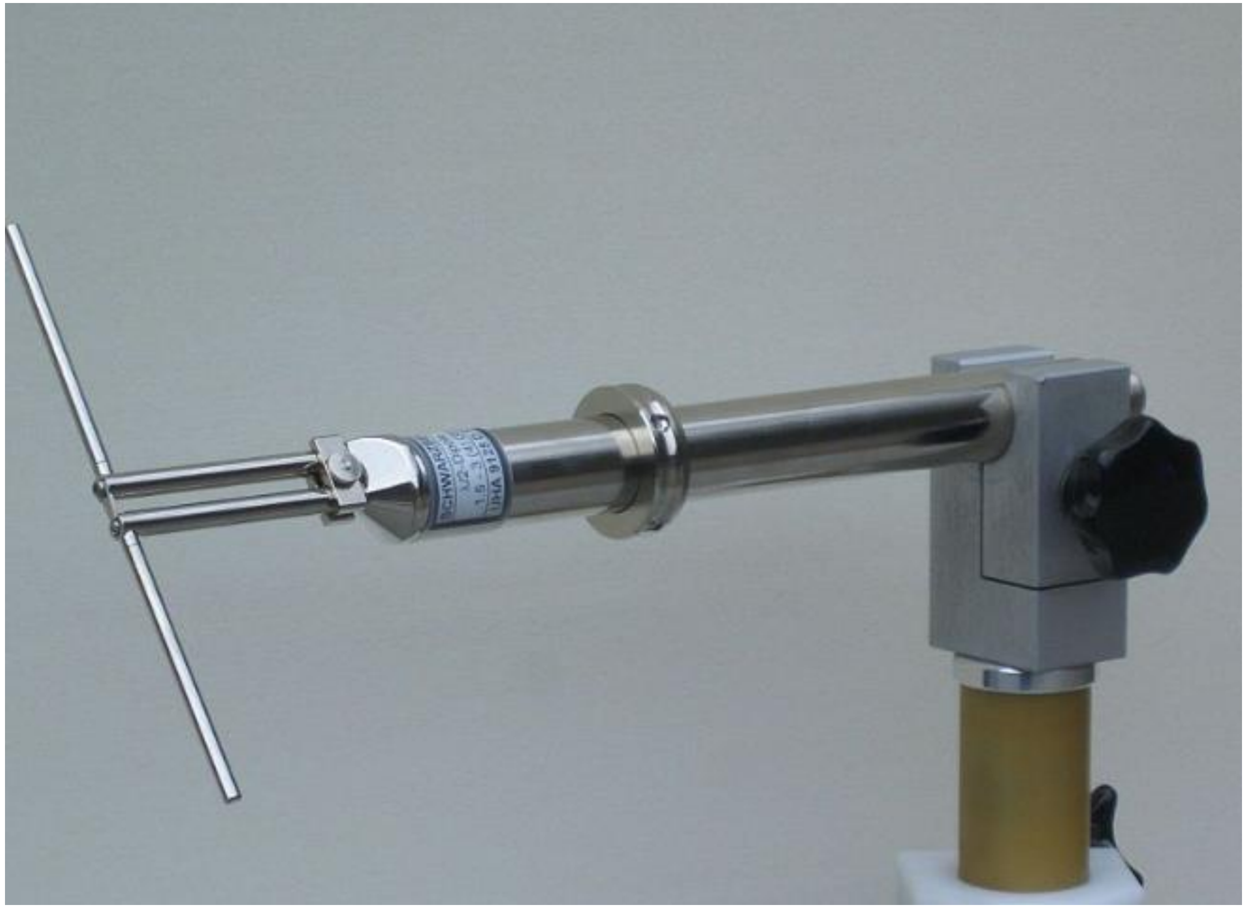
$$\vec{E}_{tot} = j\eta_0 \frac{I_0 l \beta}{4\pi} \frac{e^{-j\beta r}}{r} (1 + e^{j\psi} + e^{j2\psi} + \ldots + e^{j(N-1)\psi}) \hat{a}_\theta$$

$$F_{array} = \frac{\sin^2(\frac{N\psi}{2})}{\sin^2(\frac{\psi}{2})}$$

$$(F_{array})_{\max} = N^2$$



The earth act as mirror and hence double the antenna length



https://en.wikipedia.org/wiki/Antenna_(radio)#/media/File:Canberra_Deep_Dish_Communications_Complex_-_GPN-2000-000502.jpg

Radio frequency bands

Frequency	Wavelength	Designation	Abbreviation[4]	IEEE bands[5]
3–30 Hz	10^5–10^4 km	Extremely low frequency	ELF	-
30–300 Hz	10^4–10^3 km	Super low frequency	SLF	-
300–3000 Hz	10^3–100 km	Ultra low frequency	ULF	-
3–30 kHz	100–10 km	Very low frequency	VLF	-
30–300 kHz	10–1 km	Low frequency	LF	-
300 kHz – 3 MHz	1 km – 100 m	Medium frequency	MF	-
3–30 MHz	100–10 m	High frequency	HF	HF
30–300 MHz	10–1 m	Very high frequency	VHF	VHF
300 MHz – 3 GHz	1 m – 10 cm	Ultra high frequency	UHF	UHF, L, S
3–30 GHz	10–1 cm	Super high frequency	SHF	S, C, X, Ku, K, Ka
30–300 GHz	1 cm – 1 mm	Extremely high frequency	EHF	Ka, V, W, mm
300 GHz – 3 THz	1 mm – 0.1 mm	Tremendously high frequency	THF	-