Hertz Experiment of Electromagnetic Waves

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GROUP INDEX

Refractive index is defined as

$$n = \frac{Velocity\ of\ light_{vacuum}}{Velocity\ of\ light_{medium}}$$

$$n = \frac{c}{V_p} \qquad V_p = \frac{c}{n} = \frac{\omega}{k}$$

$$ck = n\omega$$

$$c\frac{d}{d\omega}(k) = \frac{d}{d\omega}(n\omega)$$

$$\frac{dk}{d\omega} = \frac{1}{c}\frac{d}{d\omega}(n\omega) \longrightarrow (1)$$

$$Group\ velocity, V_g = \frac{d\omega}{dk}$$

$$\frac{1}{V_g} = \frac{dk}{d\omega} \longrightarrow (2)$$

$$\frac{1}{V_g} = \frac{dk}{d\omega} = \frac{1}{c}\frac{d}{d\omega}(n\omega)$$

$$\frac{1}{V_g} = \frac{dk}{d\omega} = \frac{1}{c}\left[n\frac{d\omega}{d\omega} + \omega\frac{dn}{d\omega}\right]$$

$$\frac{1}{V_g} = \frac{dk}{d\omega} = \frac{1}{c}\left[n + \omega\frac{dn}{d\omega}\right]$$

$$\frac{1}{V_g} = \frac{dk}{d\omega} = \frac{\left[n + \omega\frac{dn}{d\omega}\right]}{c} = \frac{n_g}{c}$$

$$n_g = n + \omega\frac{dn}{d\omega} \longrightarrow (3)$$

In terms of wavelength Group Index is written as

$$\omega\frac{dn}{d\omega} = \frac{2\pi c}{\lambda}\frac{dn}{d\left(\frac{2\pi c}{\lambda}\right)}$$

$$= \frac{\cancel{(2\pi c)}}{\lambda}\frac{dn}{\cancel{(2\pi c)}\,d\left(\lambda^{-1}\right)} = \frac{1}{\lambda}\frac{dn}{d\left(\lambda^{-1}\right)}$$

$$\frac{d}{dx}uv = u\frac{dv}{dx} + v\frac{du}{dx}$$

$$\omega\frac{dn}{d\omega} = \frac{1}{\lambda}\frac{dn}{(-)\lambda^{-2}d\lambda}$$

$$\omega\frac{dn}{d\omega} = -\lambda\frac{dn}{d\lambda}$$

$$n_g = n - \lambda\frac{dn}{d\lambda} \longrightarrow (4)$$

Hertz Experiment

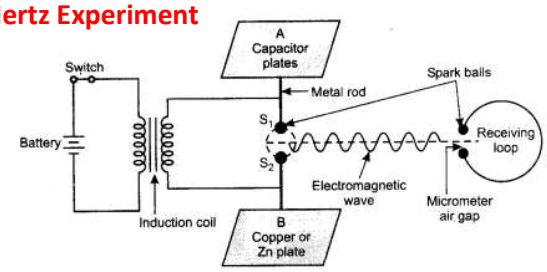
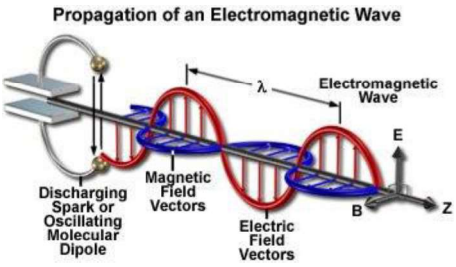


Fig : Sketch of the apparatus used by Hertz for producing and detecting radiowaves



- The existence of electromagnetic wave was confirmed experimentally by Hertz in 1888. This experiment is based on the fact that an oscillating electric charge radiates electromagnetic waves. The energy of these waves is due to kinetic energy of the oscillating charge.

- The experiment arrangement is as shown in figure. It consists of two metal plates A and B placed at a distance of 60 cm from each other. The metal plates are connected to two polished metal spheres S_1 and S_2 by means of metal rods. Using an induction coil a high potential difference is applied across the small gap between the spheres.

- Due to high potential difference across S_1 and S_2, the air in small gap between the spheres get ionized and provides a path for the discharge of the plates. A spark is produced between S_1 and S_2 and electromagnetic waves of high frequency radiated.

- Hertz was able to produce electromagnetic waves of frequency about 5×10^7 Hz. Here the plates A and B acts an a capacitor having small capacitance value C and connecting wire provide low inductance L. Thus the plates and the rods (with spheres) constitute an LC combination. The high frequency oscillation of charges between the plates is given by

$$\nu = \frac{1}{2\pi\sqrt{LC}}$$