INTRODUCTION

An important mode of transfer of energy from one point to another is *wave motion*. The transportation of energy over large distance is possible in the form of waves. We have already studied longitudinal waves, transverse waves, their properties & propagation. *Wave motion* is defined as , "The motion of an oscillatory disturbance travelling through a medium without change of form." When waves travel through a medium , they do not carry the particles with them.

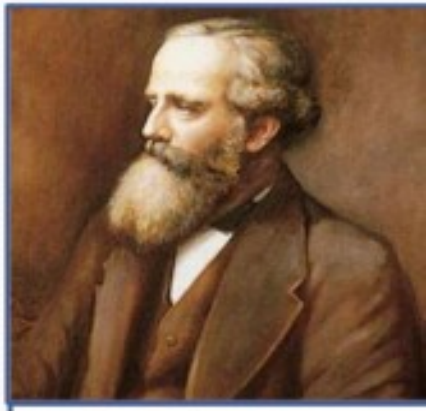
The Electromagnetic waves can travel through vacuum as well as through solids , liquids & gases. Infrared rays, the microwaves, radio waves, X rays, UV rays consist of time varying electric & magnetic fields which are the examples of electromagnetic waves.

ELECTROMAGNETIC WAVES

Charles Augustin de Coulomb studied force between two electric charges. In 1820 A.D. Oersted discovered that a current carrying conductor or wire produces a magnetic field around it. We know that the current is the rate of flow of charge, so we can say that a moving charge produces a magnetic field in the surrounding space. There is an electric field associated with charge, so moving charge is equivalent to a moving electric field. Therefore it is possible to get a magnetic field by moving electric field. Ampere showed that two long straight parallel conductors carrying currents in the same direction attract each other while in opposite direction repel each other. Michael Faraday showed that a varying magnetic field induces an e.m.f. in a coil. Thus the electric field & magnetic field are found to be linked with each other.

CHARLES AUGUSTIN DE COULOMB

James Clerk Maxwell theoretically predicted interlinking between electricity & magnetism i.e. a change in either electric or magnetic field with time produces the other field. He proposed that an oscillating electric charge radiates energy in the form of electromagnetic waves. Thus energy can be propagated in the form of electromagnetic waves. Electromagnetic waves are periodic changes in electric & magnetic fields, which propagate through space.



JAMES CLERK MAXWELL

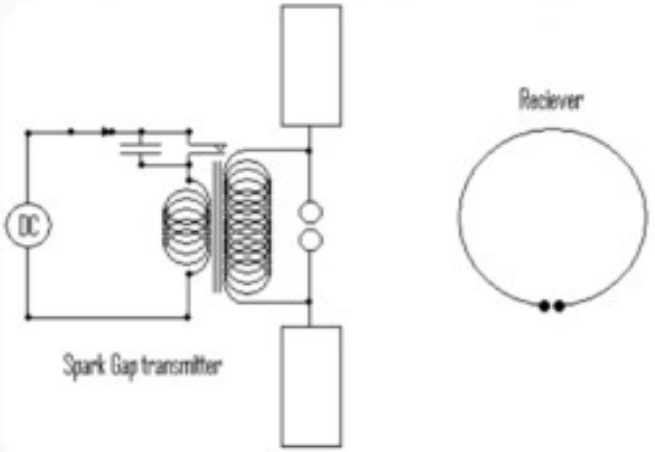
PRODUCTION OF ELECTROMAGNETIC WAVES : HERTZ EXPERIMENT.

H.R. HERTZ

In 1888 H.R. Hertz succeeded in producing & detecting the existence of electromagnetic waves & also demonstrated their properties of reflection, refraction & interference.

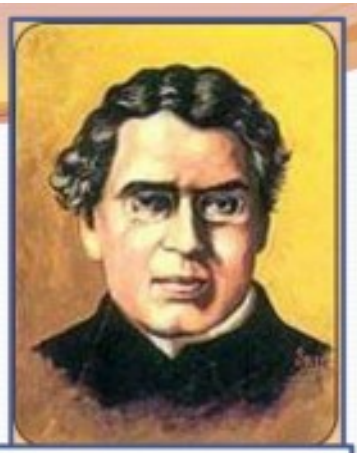
As experimental setup used by Hertz to produce & detect electromagnetic waves is shown in given figure.

The thermistor consist of two spheres S_1 & S_2 located near the ends of two straight rods A & B separated by a spark gap S. with the two rods connected to an induction coil I, sparks jump across the gap S, giving rise to an oscillatory currents in A & B. the spheres S_1 & S_2 act as the plates of a capacitor & the rods A & B provide inductance. Hence the transmitter acts as an oscillator circuit.

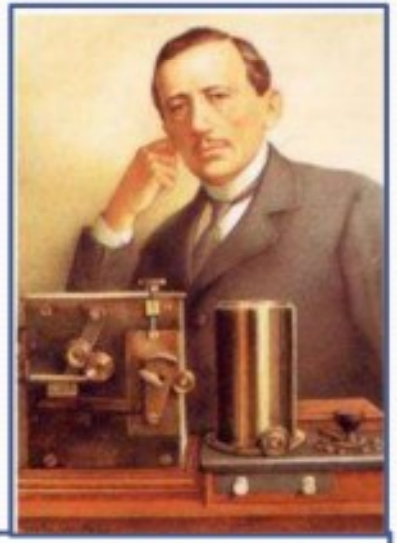


The receiver or detector, consist of a single loop of wire with a tiny spark gap at R. The circuit too, is an oscillating circuit with the spark gap acting as a capacitor & the loop providing the inductance. Tuning the transmitter frequency so that the receiver is done by sliding the spheres S_1 & S_2 along the rods A & B. When the two circuits are tuned, a spark appears across R, whenever a spark passes across S. With this apparatus, Hertz was able to transmit signals from one goal past of a football field & received them at the opposite goal post, a few hundred feet away. Hertz was able to produce electromagnetic waves having wavelengths of about 6m. He also demonstrated that these waves undergo reflection, refraction, interference etc. as those of light i.e. light waves are electromagnetic waves. Using a large prism of paraffin, Hertz demonstrated that the waves could be refracted, deviated & with a lens made of pitch, he focussed the waves as a glass lens focussing visible light.

In 1895, an Indian physicist, ***Sir Jagdish Chandara Bose***, produced electromagnetic waves, ranging in wavelengths from 5mm to 25mm. His work, however, remained confined to laboratory only. In 1896, an Italian physicist, ***G. Marconi***, became the first to establish wireless communication when he transmitted & received signals across English channel, a distance of about 48km. Later, in 1901, Marconi succeeded in establishing wireless communication between Newfoundland & Cornwall, across the Atlantic ocean. He was awarded the Nobel prize in Physics in 1909, for his work in developing wireless telegraphy, telephony & broadcasting.



SIR JAGDISH CHANDRA BOSE



G. MARCONI

CHARACTERISTICS OF ELECTROMAGNETIC WAVES

1. Electromagnetic waves propagate in the form of time varying electric & magnetic fields such that the two fields are perpendicular to each other & also to the direction of propagation of the waves. Thus the electromagnetic waves are transverse in nature.

2. Electromagnetic waves do not require any material medium for their propagation. They can travel through vacuum as well as solids, liquids & gases.

3. Electromagnetic waves are produced by accelerated electric charges.

4. The relation between the velocity (**c**), frequency (**v**) & wavelength (**λ**) of electromagnetic waves in vacuum (i.e. free space) is given by

$$c = \nu\lambda.$$

5. The velocity (c) of electromagnetic waves in vacuum (i.e. free space) is given

$$c = \frac{1}{\sqrt{\mu_o \varepsilon_o}} = 3 \times 10^8 \text{ m/s}$$

where μ_o is the permeability &ε_o is the permittivity of free space.

6. In a given material medium, the velocity ($\mathbf{v_m}$) of electromagnetic waves is given by

$$\mathbf{v_m} = \frac{1}{\sqrt{\mu \varepsilon}}$$

Where μ is the permeability & ε is the permittivity of the given medium.

7. The electromagnetic waves obey the **principle of superposition** of waves.

8. The electromagnetic waves exert pressure on the surface on which they are incident.

9. The low frequency electromagnetic waves are unaffected by external electric & magnetic fields.

10. The energy of the electromagnetic waves is divided or distributed equally between the electric & magnetic field vectors.