Electromagnetic Waves

If we have charges we can have electric field.
If we have steady current we get magnetic field.
But can we have electric field and magnetic field without having charges or currents?

Yes is the answer. (provided they are once produced)
If there is changing magnetic field, it will create electric field and changing electric field will create magnetic field. So one survives at the expense of other. giving rise to an electromagnetic wave which propagates at the speed of light.

Mathematical ~~De~~ Relations.

Without any source charge or current source $\rho = 0$, $J = 0$, the Maxwell's eq in Differential form.

$$\nabla \cdot E = 0 \quad (1) \qquad \nabla \times E = -\partial B/\partial t \quad (3)$$

$$\nabla \cdot B = 0 \quad (2) \qquad \nabla \times B = \mu_0 \epsilon_0 \, \partial E/\partial t \quad (4)$$

By taking the curl of (3) & (4) eqn. one gets.

$$\boxed{\nabla^2 E = \mu_0 \epsilon_0 \frac{\partial^2 E}{\partial t^2}}$$

$$\boxed{\nabla^2 B = \mu_0 \epsilon_0 \frac{\partial^2 B}{\partial t^2}}$$

Electromagnetic Wave Eqns.

Comparing with wave Eqn we get $v = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$

$$= 3 \times 10^8 \, m/s.$$

Which is the speed of light. So he concluded That light is an electromagnetic wave. This is the most important Contribution by Maxwell.

For the first time Maxwell combined the optics with electromagnetic phenomena.

Solutions of EM. wave Equations.

Out of many one of the simplest solutions of Wave Equations are Harmonic Wave Solutions.

$$\left.\begin{aligned}\bar{E} &= \bar{E}_0 \sin(kx - \omega t) \\ \bar{B} &= \bar{B}_0 \sin(kx - \omega t)\end{aligned}\right]$$ Direction of propagation is x axis here.

Using the Maxwell's eqns we reach two very imp. Conclusions.

(1) There is no component of Electric and magnetic field in the direction of propagation

(2) $\bar{K}, \bar{E}, \bar{B}$ are all perpendicular to each other such that one gets $\bar{B}_0 = \dfrac{\bar{K} \times \bar{E}_0}{\omega}$

(3) $B_0 = E_0/c$

(4) Pictorially one can represent em wave as