SET – 01

Introduction

1. Maxwell's equations

integral form | | differential form |
|---|---|---|---|
| Gauss | $\oint d\vec{a}\cdot\vec{E} = \frac{Q}{\epsilon_0}$ | $\rightarrow$ | $\vec{\nabla}\cdot\vec{E} = \frac{\rho}{\epsilon_0}$ |
| | $\oint d\vec{a}\cdot\vec{B} = 0$ | $\rightarrow$ | $\vec{\nabla}\cdot\vec{B} = 0$ |
| Faraday | $\oint d\vec{l}\cdot\vec{E} = -\frac{\partial}{\partial t}\phi_B$ | $\rightarrow$ | $\vec{\nabla}\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}$ |
| Ampere | $\oint d\vec{l}\cdot\vec{B} = \mu_0\epsilon_0\frac{\partial}{\partial t}\phi_E + \mu_0 I$ | $\rightarrow$ | $\vec{\nabla}\times\vec{B} = \mu_0\epsilon_0\frac{\partial\vec{E}}{\partial t} + \mu_0\vec{J}$ |

$Q = \int d^3r\, \rho(\vec{r})$

$\phi_B = \int_S d\vec{a}\cdot\vec{B}$

$\phi_E = \int_S d\vec{a}\cdot\vec{E}$

$I = \int_S d\vec{a}\cdot\vec{J}$

2. Classical mechanic neglects
$$\begin{cases} \text{(i) relativistic effects} & \frac{v}{c} << 1 \\ \text{(ii) quantum effects} & \Delta p\,\Delta x >> \hbar \end{cases}$$

→ space craft & moon – mostly classical mechanics.

→ Light emission by atoms (LASER) – quantum mechanics.

→ pair production, Casimir effect – quantum (relativistic) electrodynamics.

3 Quantum electrodynamics ~~is~~ describes the interaction of photons and electrons (positrons).

PHOTONS $\longleftrightarrow$ ELECTRONS (POSITRONS) $\rightarrow$ (OR ANY charged particle)

mass = 0
charge = 0
spin = 1

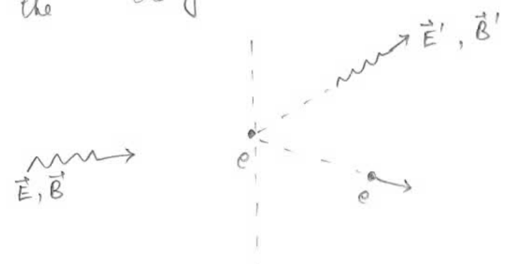
mass = 9.1×10^{-31} kg
charge = $\pm 1.6 \times 10^{-19}$ C.
spin = $\frac{1}{2}$.

ELECTROMAGNETIC field $\longleftrightarrow$ WAVE FUNCTION

$\vec{E}(\vec{r},t)$ & $\vec{B}(\vec{r},t)$

$\psi(\vec{r},t)$

4 In this course we will neglect the dynamics of the charged particles.



Analogy: while studying the motion of a ball thrown by a boy on Earth, we can neglect the dynamics of Earth.

(5) Examples of quantum electrodynamic phenomena that can not be understood by neglecting relativistic or quantum effects.

→ pair production by electric field

$|\vec{E}_{threshold}| \sim 10^{16} \frac{V}{cm}$

$|\vec{E}_{threshold}|$ for atmospheric breakdown is $10^{4} \frac{V}{cm}$.

→ Casimir effect

two (neutral) metallic objects attract in vacuum.