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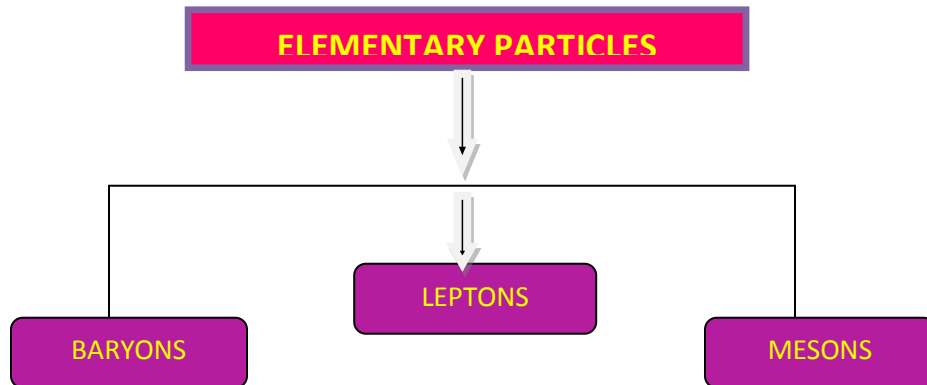
NUCLEAR PHYSICS-16SCCPH8

UNIT-V

ELEMENTARY PARTICLES

CLASSIFICATIONS OF ELEMENTARY PARTICLES:

There are three types:



BARYONS (Heavy Particles): Every baryon has an antiparticle

- ❖ Proton
- ❖ Neutron
- ❖ Lambda
- ❖ Sigma
- ❖ Xi
- ❖ Omega

Lambda, Xi, Omega is HYPERONS. Every Baryon has an antibaryons.
+1 is assigned baryon. -1 is assigned for anti baryons.

MESONS: Are particles of strong interaction

- ❖ Pion
- ❖ Kaon
- ❖ Eta

The rest mass of these particles varies between about $250m_e$ and $1000m_e$. The mesons are the agents of interaction between particles inside the nucleus. Baryons and mesons are jointly called HADRONS.

LEPTONS: This group contains

- ❖ Photon
- ❖ Neutrino
- ❖ Electron
- ❖ Muon

PARTICLES AND ANTI PARTICLES:

- ❖ Electron – Positron
- ❖ Proton -antiproton
- ❖ Neutron-antineutron
- ❖ Neutrino- antineutrino

FUNDAMENTAL INTERACTIONS:

Four basic interactions are summarised below

1. Strong interaction:

- ❖ A familiar example of strong interaction is nuclear forces.
- ❖ It is independent of electric charge
- ❖ Range is about 10^{-15} m
- ❖ Time interval is about 10^{-23} s

2. Electromagnetic Interaction:

- ❖ It operate on all charges
- ❖ It is charge dependent
- ❖ The range is infinite
- ❖ Interaction through photons
- ❖ Example electron- positron pair from gamma rays

3. Weak interactions:

- ❖ Time interval is about 10^{-10} s.
- ❖ Range is less than 10^{-17} m
- ❖ Characteristic time about 10^{-10} s
- ❖ It is responsible for decay of strange and non-strange particles and for non leptonic of strange particles.

4. Gravitational Interactions:

- ❖ Weakest type of interactions
- ❖ It has infinite range
- ❖ Intermediate through gravitons
- ❖ Weak forces affect every particles other than photon.

PIONS AND MUONS:

Pi mesons are particles with mass intermediate between that of an electron and a proton. To explain the short range of internucleonic force, the pion considered as a quantum of this force.

It was predicted by Yukawa. Subsequently it was discovered by Powell and co-workers.

Its(π^0) mass is about $135\text{Mev}/c^2$ or about 250 times the electron mass with integral spin. Charged pions have mass of $140\text{ Mev}/c^2$. All pions strongly interacted with matter.



Muons like a charged pions, are also elementary particles with mass intermediate between that of an electron and a proton. It has a mass only $106\text{ Mev}/c^2$ and does not interact strongly with matter. Its spin $\frac{1}{2}$. Muons are electrically charged either

positively or negatively and it carry one unit of charge. They are unstable particles and emit electrons. Muons also discovered in cosmic radiation.

K-MESONS OR KOANS:

- ❖ While working with a counter controlled cloud chamber in a strong magnetic field, with a lead sheet interposed along the diameter of the chamber, Rochester and Butler observed a pair of tracks of oppositely charged pions originating apparently at a common point. It was not a case of collision process producing the pair, for then a host of other particles would have originated in the lead plate. The event was

Attributed to spontaneous disintegration of a neutral particle that left no track in the chamber and the particle was termed as K^0 meson.

The disintegration was represented as



- ❖ K mesons are charged positively and negatively K^+ and K^- that decay into three charged pions.



- ❖ All K decays assigned to single group of mesons are called K mesons or Kaons. Both charged and neutral. Masses being $975 m_e$ for K^0 and $966 m_e$ for K^+ and K^- .
- ❖ The mean life of Kaon about 10^{-10} to 10^{-8} s.
- ❖ It is the characteristic of the weak interaction decays.

- ❖ Kaons are known as the strange particles
- ❖ All Kaons have zero spin, they are bosons.
- ❖ Kaons available in giant accelerators.

PIONS OR π - MESONS:

- ❖ Discovered by 1947 \rightarrow in the cosmic rays.
- ❖ Exist the three state $\rightarrow \pi^+, \pi^-,$ and π^0 .
- ❖ The π^+, π^- are antiparticles of each other.
- ❖ π^+, π^- mesons have a rest mass of $273m_e$.
- ❖ The rest mass of π^0 mesons is $264m_e$.
- ❖ The pions a mean life \rightarrow unstable of $2.6 \times 10^{-8} s$.
- ❖ The charged pions decay into corresponding muons and neutrino.

$$\pi^+ \rightarrow \mu^+ + \nu_\mu$$

$$\pi^- \rightarrow \mu^- + \nu_\mu$$

The neutral pion has a mean life of $8.7 \times 10^{-17} s$ and decay into two gamma rays. $\pi^0 \rightarrow \gamma + \gamma$

μ^+ & μ^- [positive and negative muons] have the same rest mass of $106 \text{ Mev}/c^2$ the same spin of $\frac{1}{2}$.

Both decay with a relatively long mean life of $2.2 \times 10^{-6} s$ into electron and neutrino antineutrino pions.

$$\mu^+ \rightarrow e^+ + \nu_e + \bar{\nu}_\mu$$

$$\mu^- \rightarrow e^- + \nu_\mu + \bar{\nu}_e$$

