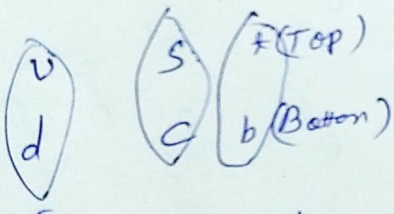
12/07/22

The Quark Model (classification of hadrons)

In 1964, by Murrey Gell-man and independently Zweig introduced a baryonic triplet, consisting of three hypothetical particles called Quarks.

→ Q.M is able to explain many features of the elementry particles and give insight into the structure of the group of hadrons (baryons and mesons) of the elementry particles.

Three Quarks (originally)



1st gen 2nd 3rd - generation

→ Six different flavors of Quarks

Properties

(1) 6 flavours of quarks

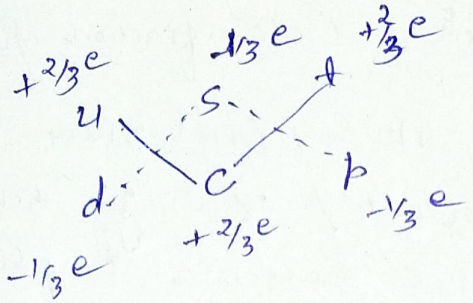
q : u d s c t b

$\bar{q}$: $\bar{u}$ $\bar{d}$ $\bar{s}$ $\bar{c}$ $\bar{t}$ $\bar{b}$

(2) Spin: $\Rightarrow 1/2$ for Quarks (fermions)

(3) Baryon number $B = 1/3$

(4) Charge: All quarks have fractional charges either $-1/3\,e$ or $+2/3\,e$



Note: diagonal particles have equal charge.

Different Quantum no. of quarks:

Quantum numbers

Quark flavour	change	I	I_z	u	d	s	c	t	b
u	$+\frac{2}{3}e$	$+\frac{1}{2}$	$+\frac{1}{2}$	+1	0	0	0	0	0
d	$-\frac{1}{3}e$	$+\frac{1}{2}$	$-\frac{1}{2}$	0	-1	0	0	0	0
s	$-\frac{1}{3}e$	0	0	0	0	-1	0	0	0
c	$+\frac{2}{3}e$	0	0	0	0	0	+1	0	0
t	$-\frac{1}{3}e$	0	0	0	0	0	0	-1	0
b	$\frac{2}{3}e$	0	0	0	0	0	0	0	+1

Note: The Qua. no. has sign acc. to the sign of change of diffent Quark flavours.

Antiquark:

Antiquarks : (1) The isospin of quark & antiquark are same.

(2) The quark & antiquarks have opposite (1) strangess (S)

(2) charge (Q)

(3) Baryon no. (B)

(4) I_z (I_z)

Hadrons

Mesons (B = 0) | Baryons (B = 1)

quark composition ($q\bar{q}$) | (qqq) (3 quarks)

$\frac{1}{3} - \frac{1}{3} = 0$ | $\frac{1}{3}+\frac{1}{3}+\frac{1}{3}$ (B = 1.)

so B = 0

For writing quarks structure three quantities must be satisfied

(1) strangeness (strange particles formed through strong interaction & decay by weak interaction)

(2) Charge

(3) Isospin (strong interaction can not distinguish between charges for (n & p) so, isospin (I_z) third component of isospin was introduced.

Quark Structure of Meson

particle

$S=1$ K^+

$I=1/2$

Quark structure.

$(u\bar{s})$ (for strange particle $s=1$

$\frac{2}{3}+\frac{1}{3}$ $\bar{s}=+1$

(∵ look for total charge.

∵ Isospin : u has $+1/2$ isospin

(s, a, z all are satisfied)

likewise for all other meson particles one can write quark structure.

K^0 $(d\bar{s})$

K^- $(\bar{u}s)$

$\bar{K}^0$ $(\bar{d}s)$

π^+ $(u\bar{d})$

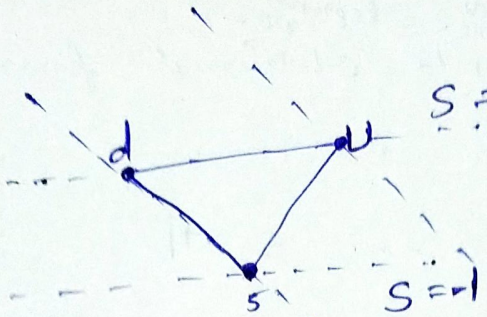
π^0 $(u\bar{u}, d\bar{d})$

π^- $(\bar{u}d)$

η^0 $(u\bar{u}, d\bar{d}, s\bar{s})$

Quark model

inverted triangle



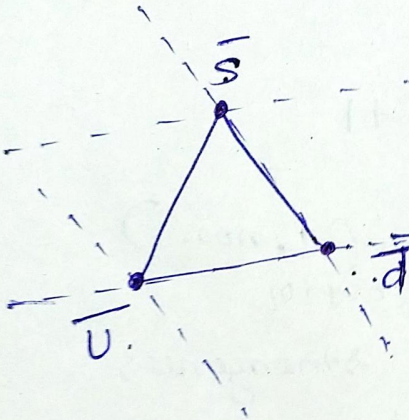
$S = 0$

$S = -1$

$q = +\frac{2}{3} e$

$q = -1/3\, e$

Anti quark model



$S = 1$

$S = 0$

$q = +1/3\, e$

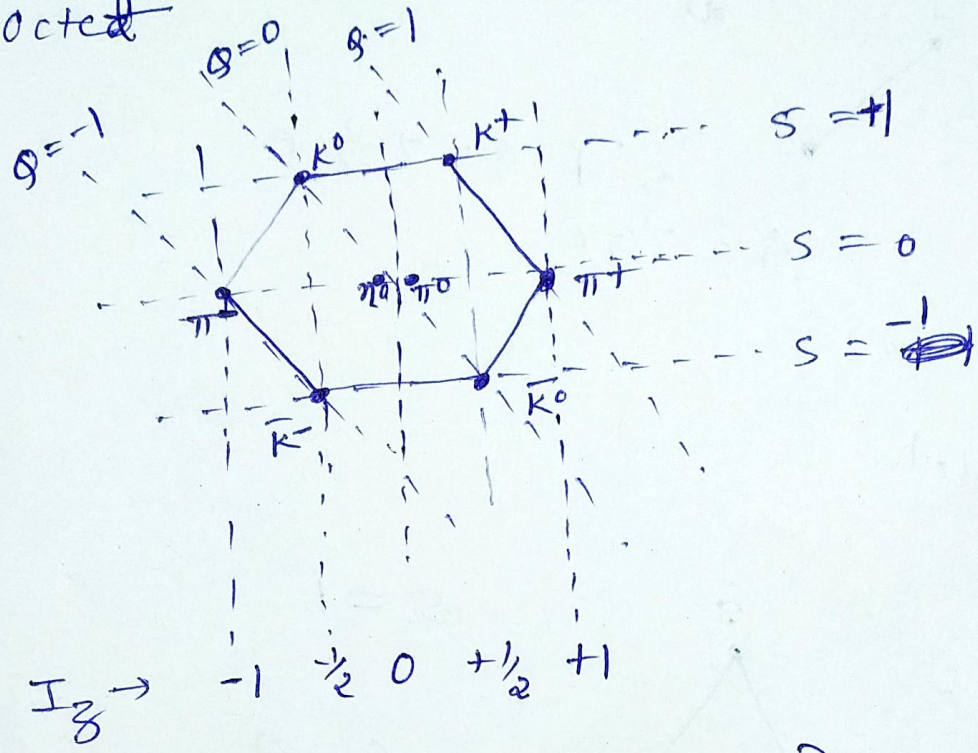
$q = -\frac{2}{3} e$

Meson Octet ($B=0$, $L=0$)

Baryon no. lepton no.

All the properties can be obtained from meson octet

$J = 0^-$

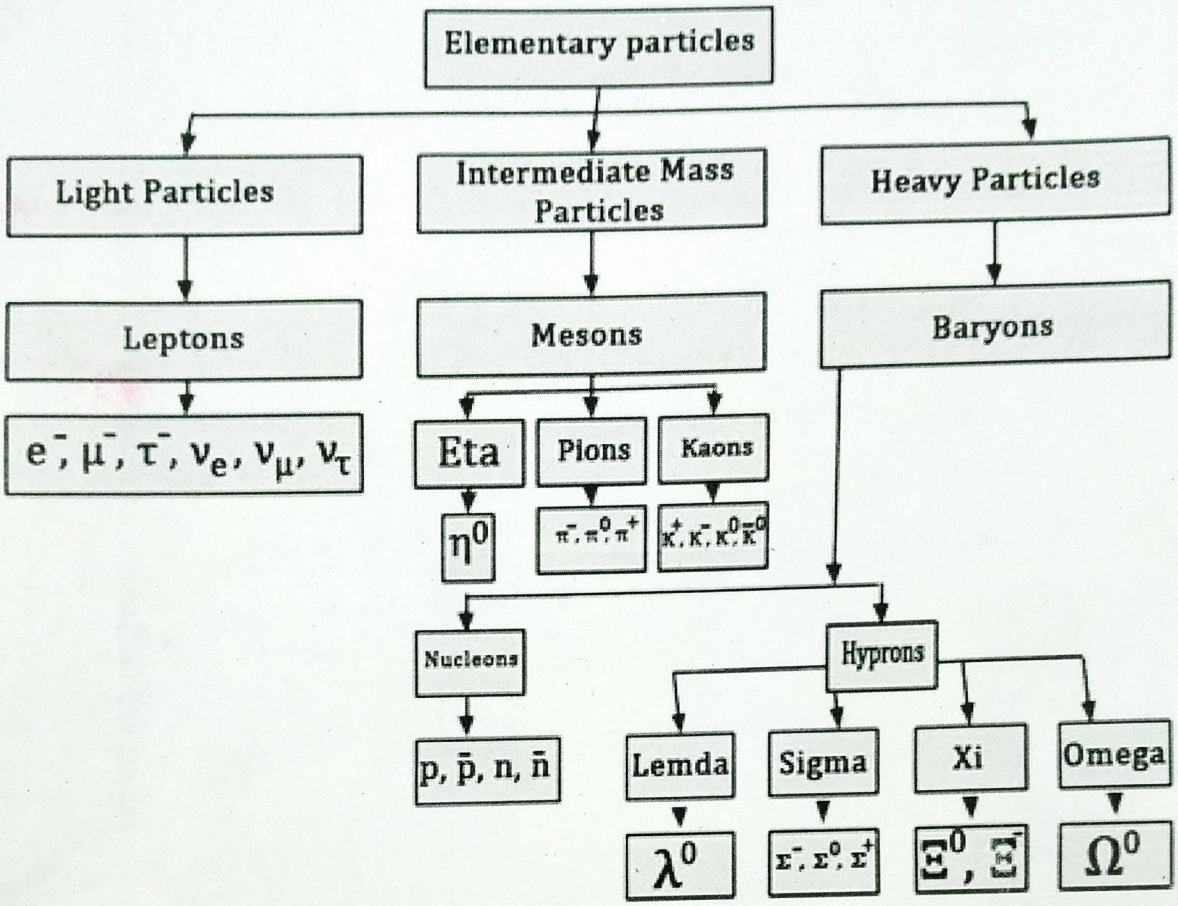


(q. nos.)

Vertical lines → Isospin

Horizontal lines → Strangeness

diagonal lines → charge


Elementary particles
Light Particles
Intermediate Mass Particles
Heavy Particles
Leptons
Mesons
Baryons
$e^-, \mu^-, \tau^-, \nu_e, \nu_\mu, \nu_\tau$
Eta
Pions
Kaons
η^0
π^-, π^0, π^+
$K^+, K^-, K^0, \bar{K}^0$
Nucleons
Hyprons
p, $\bar{p}$, n, $\bar{n}$
Lemda
Sigma
Xi
Omega
λ^0
$\Sigma^-, \Sigma^0, \Sigma^+$
Ξ^0, Ξ^-
Ω^0