The Sakata model

This model extends the old ideas of Fermi and Yang (1949) that pions are bound states of a nucleon and an antinucleon. If we want to account for kaons similarly, then we need a heavy constituent which carries a unit of strangeness and we choose Λ^0. Sakata therefore, proposed that p, n and Λ^0 are the fundamental particles, from which the others are made up. Thus:

$$|\pi^+\rangle = |p\bar{n}\rangle$$

$$|\pi^-\rangle = |\bar{p}n\rangle$$

$$|\pi^0\rangle = \frac{1}{\sqrt{2}}\left(|p\bar{p}\rangle + |n\bar{n}\rangle\right), \quad \eta^0 = \frac{1}{\sqrt{2}}\left(|p\bar{p}\rangle - |n\bar{n}\rangle\right)$$

$$|K^+\rangle = |p\bar{\Lambda}^0\rangle$$

$$|K^-\rangle = |\Lambda^0\bar{p}\rangle$$

$$|\Sigma^+\rangle = |\Lambda^0 p\bar{n}\rangle = |\Lambda\pi^+\rangle, \quad \Sigma^0 = |\Lambda\pi^0\rangle, \quad \Sigma^- = |\Lambda\pi^-\rangle$$

$$|\Xi^-\rangle = |\Lambda^0\Lambda^0\bar{p}\rangle = |\Lambda K^-\rangle, \quad \Xi^0 = |\Lambda\bar{K}^0\rangle = |\Lambda^0\Lambda^0\bar{n}\rangle$$

Quark Model

It was because of the failure of Sakata model, that Gell-Mann and Ne'eman put the n, p, Λ triplet into an octet together with Σ and Ξ. Instead they considered the Baryons and Mesons as composites of a fundamental triplet of $SU(3)$.

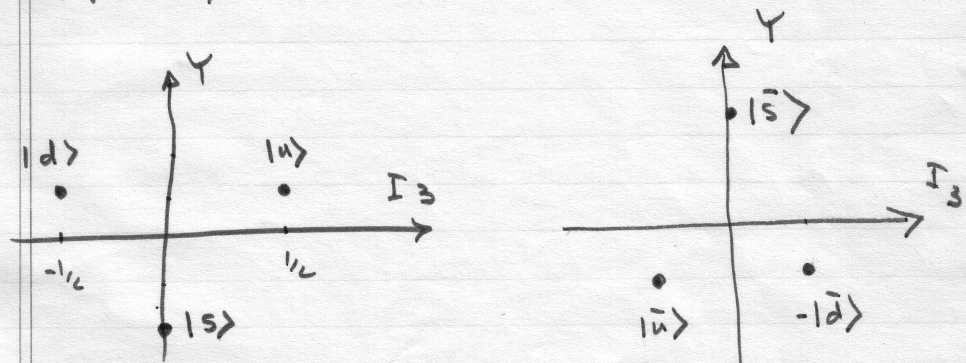
$$\text{Baryons} = (q\,q\,q)$$
$$\text{Mesons} = (q\,\bar{q})$$

THE QUARK MODEL

The basic assumptions of quark model are as follows:

a) There exist a fundamental triplet of strongly interacting particles, called quarks, denoted by u, d and s.

b) The observed hadrons are bound state of two or more quarks / antiquarks.

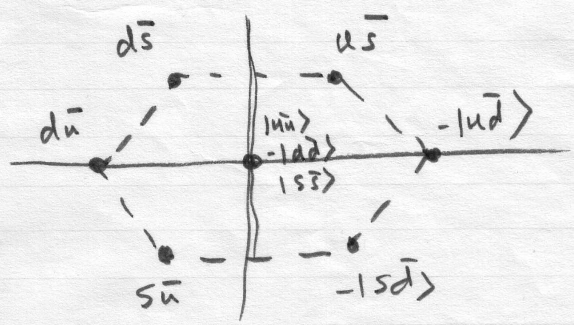


Weight diagram for 3 - quark and $\bar{3}$ - quark.

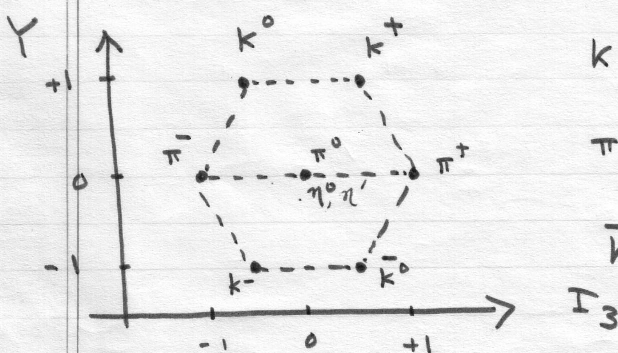
If the binding forces are symmetrical with respect to the three quarks, then the model is invariant under SU(3) and bound states must form multiplets.

Quark structure of mesons

pseudoscalar	vector	Quark-structure
K^+	K^{+*}	$\lvert u\bar{s}\rangle$
K^0	K^{0*}	$\lvert d\bar{s}\rangle$
π^+	ρ^+	$-\lvert u\bar{d}\rangle$
π^0	ρ^0	$\frac{1}{\sqrt{2}}\left(\lvert u\bar{u}\rangle - \lvert d\bar{d}\rangle\right)$
π^-	ρ^-	$\lvert d\bar{u}\rangle$
η^0	ϕ_8	$\frac{1}{\sqrt{6}}\left[-\lvert u\bar{u}\rangle - \lvert d\bar{d}\rangle + 2\lvert s\bar{s}\rangle\right]$
$\overline{K}^0$	$\overline{K}^{0*}$	$-\lvert s\bar{d}\rangle$
K^-	K^{-*}	$\lvert s\bar{u}\rangle$
η^0	ω	$\frac{1}{\sqrt{3}}\left[\lvert u\bar{u}\rangle + \lvert d\bar{d}\rangle + \lvert s\bar{s}\rangle\right]$



Meson multiplets

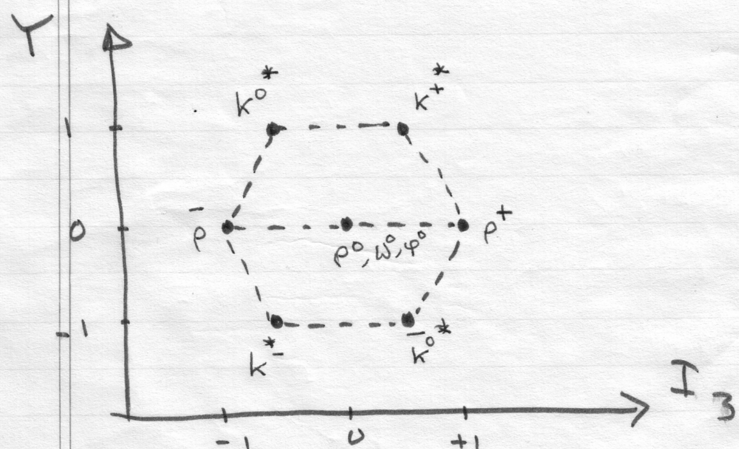


K (496)

π (138), η(549), η'(958) → singlet

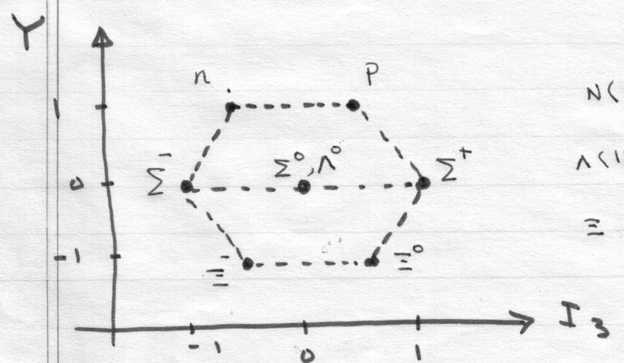
$\bar{K}$ (496)

$$J^P = 0^-$$



$$J^P = 1^-$$

baryon multiplet:

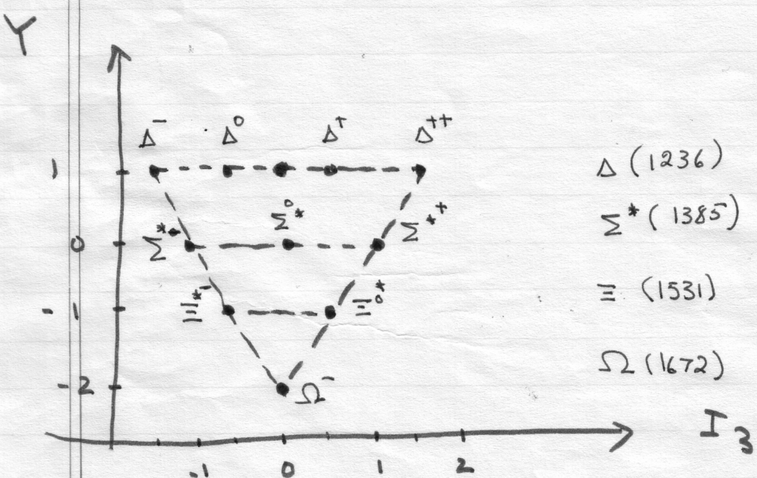


N(939)

Λ(1116), Σ(1193)

Ξ (1318)

$J^P = 1/2^+$



Δ (1236)

Σ* (1385)

Ξ (1531)

Ω (1672)

$J^P = 3/2^+$