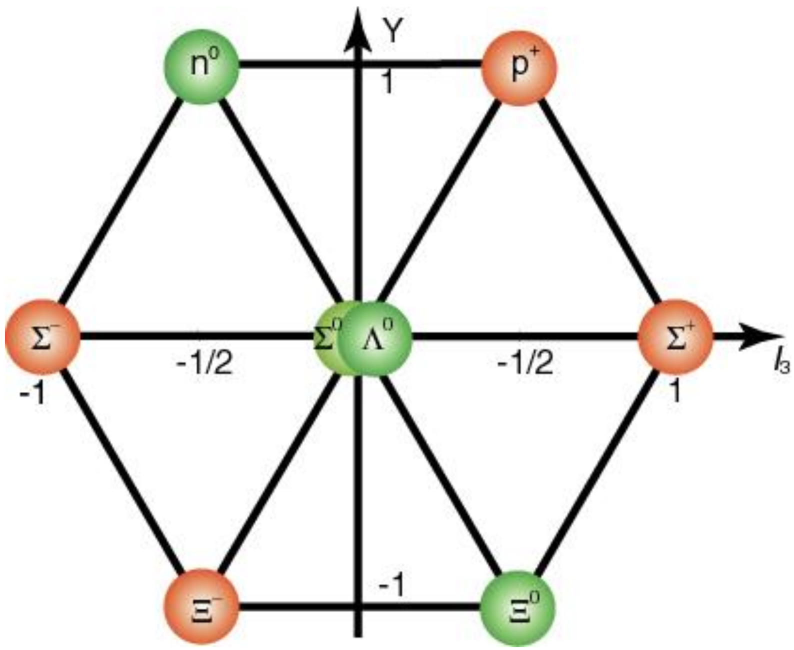
Кварков модел
Ароматна симетрия



Нека разгледаме u и d кварките, като базисни (единични ортогонални) вектори в двумерно пространството

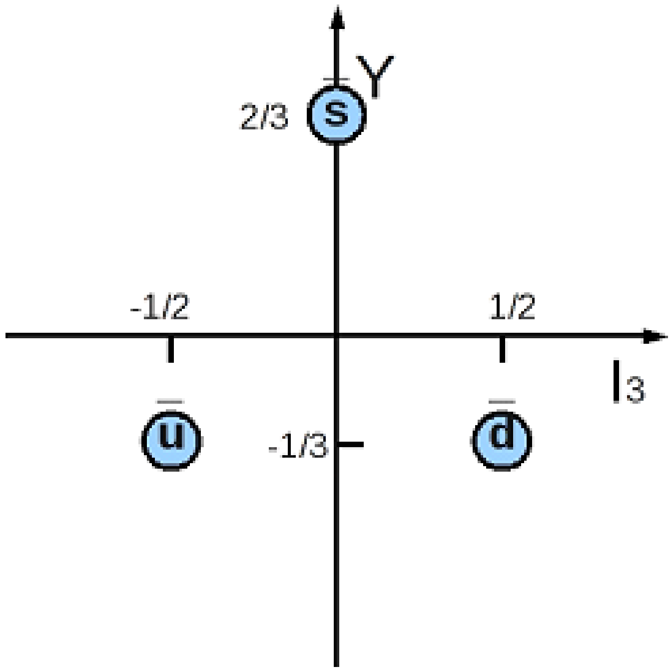
(на изотопичния спин)

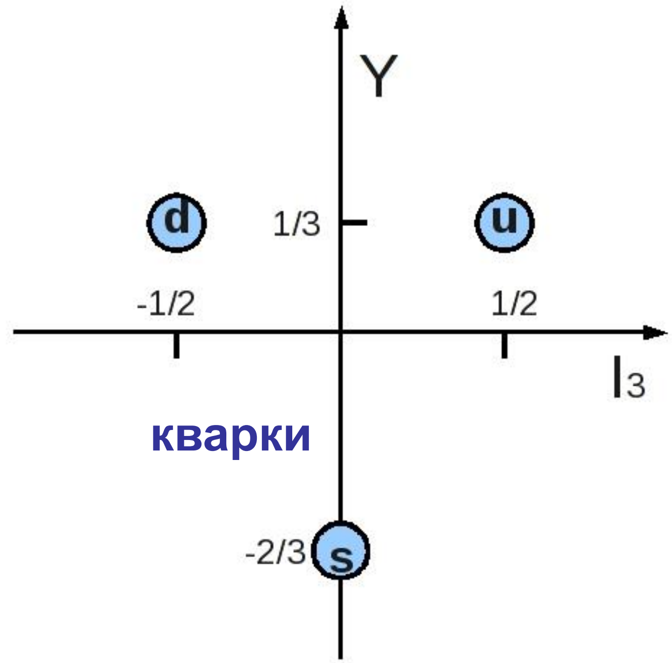
Таблица 10.10. Тази таблица показва близката аналогия между спина и изотопичния спин при конструирането на състояния с по-висок спин от базисните състояния.

	Спинов момент на импулса			Изотопичен спин		
	квантови числа		вектори на състоянието	квантови числа		вектори на състоянието
Базисни състояния						
Дублет	$s=\frac{1}{2}$	$s_z=-\frac{1}{2}$	$\vert\downarrow\rangle$	$t=\frac{1}{2}$	$t_3=-\frac{1}{2}$	$\vert d\rangle$
		$s_z=+\frac{1}{2}$	$\vert\uparrow\rangle$		$t_3=+\frac{1}{2}$	$\vert u\rangle$
Векторно събиране на два спина						
Синглет	$s=0$	$s_z=0$	$\frac{1}{\sqrt{2}}\vert\uparrow\downarrow-\downarrow\uparrow\rangle$	$t=0$	$t_3=0$	$\frac{1}{\sqrt{2}}\vert ud-du\rangle$
Триплет	$s=1$	$s_z=-1$	$\vert\downarrow\downarrow\rangle$	$t=1$	$t_3=-1$	$\vert dd\rangle$
		$s_z=0$	$\frac{1}{\sqrt{2}}\vert\uparrow\downarrow+\downarrow\uparrow\rangle$		$t_3=0$	$\frac{1}{\sqrt{2}}\vert ud+du\rangle$
		$s_z=+1$	$\vert\uparrow\uparrow\rangle$		$t_3=+1$	$\vert uu\rangle$

S =

SU(3) ароматна симетрия

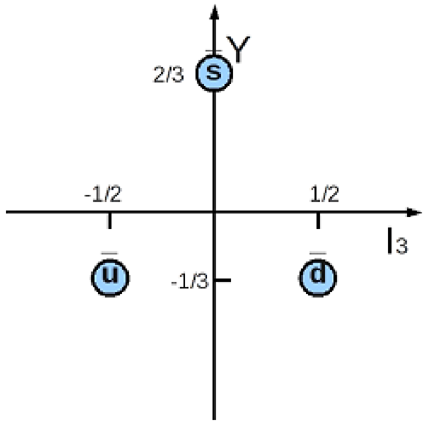




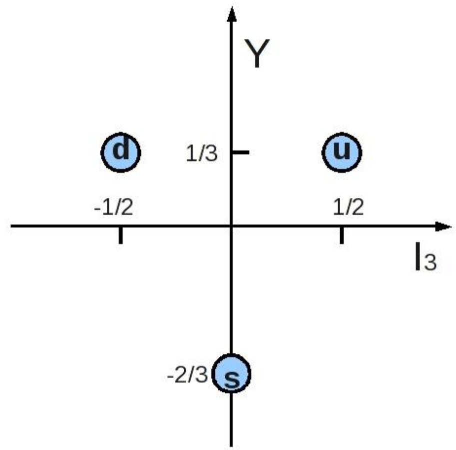
Ароматите на кварките са неразличими от гледна точка на силното взаимодействие. Симетрията би била точна, ако масите на кварките бяха еднакви.

Мезони

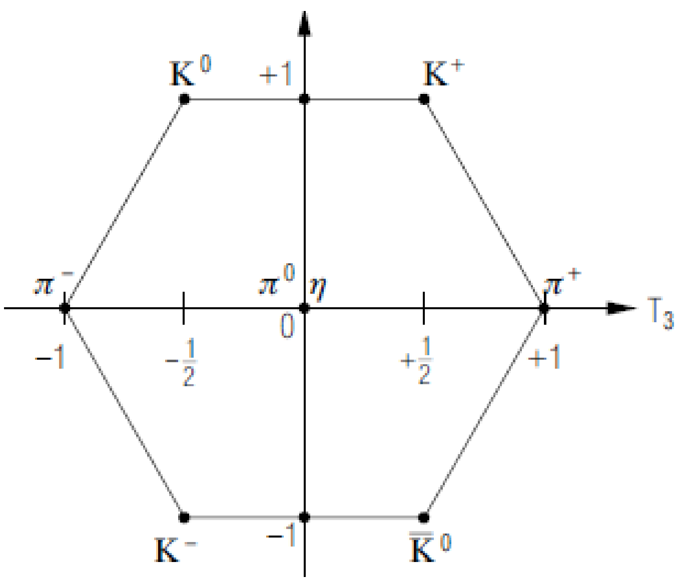
$$\bar{M}(q^1\bar{q}^2) \qquad 3\otimes\bar{3}=8\oplus 1$$



$\otimes$



$=$



$\oplus \quad \eta'$

Гръцките букви са на привършване...

MeV/c²

$$\pi^+(140) \to u\bar{d}\,; \quad \pi^-(140) \to \bar{u}d\,; \quad \pi^0(135) \to \tfrac{1}{2}(u\bar{u} - d\bar{d})$$

$$K^0(498) \to d\bar{s}\,; \quad \overline{K^0}(498) \to \bar{d}s\,; \quad \eta(550) \to \tfrac{1}{\sqrt{6}}(u\bar{u} + d\bar{d} - 2s\bar{s})$$

$$K^+(494) \to u\bar{s}\,; \quad K^-(494) \to \bar{u}s\,; \quad \eta'(960) \to \tfrac{1}{\sqrt{3}}(u\bar{u} + d\bar{d} + s\bar{s})$$

$J^P=0^-$

$$\rho^+(770) \to u\bar{d}\,; \quad \rho^-(770) \to \bar{u}d\,; \quad \rho^0(770) \to \tfrac{1}{\sqrt{2}}(u\bar{u} - d\bar{d})$$

$$K^{*0}(896) \to d\bar{s}\,; \quad \overline{K^{*0}}(896) \to \bar{d}s\,; \quad \omega^0(780) \to \tfrac{1}{\sqrt{2}}(u\bar{u} + d\bar{d})$$

$$K^{*+}(892) \to u\bar{s}\,; \quad K^{*-}(892) \to \bar{u}s\,; \quad \phi(1020) \to s\bar{s}$$

$J^P=1^-$

$$m(K) > m(\pi) \qquad m(\pi) < m(\rho)$$

135 MeV vs. 770 MeV

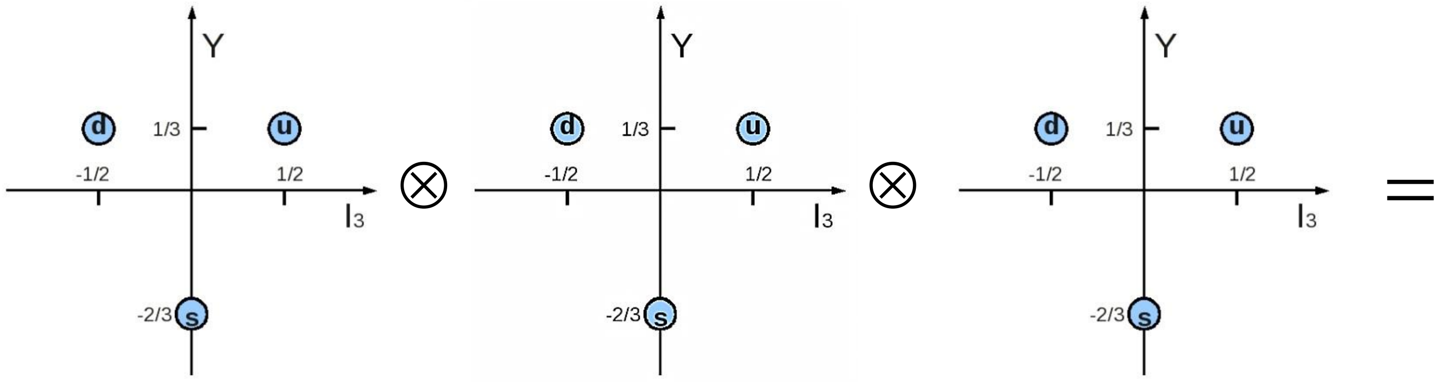
$$\Rightarrow m_s > m_u, m_d$$

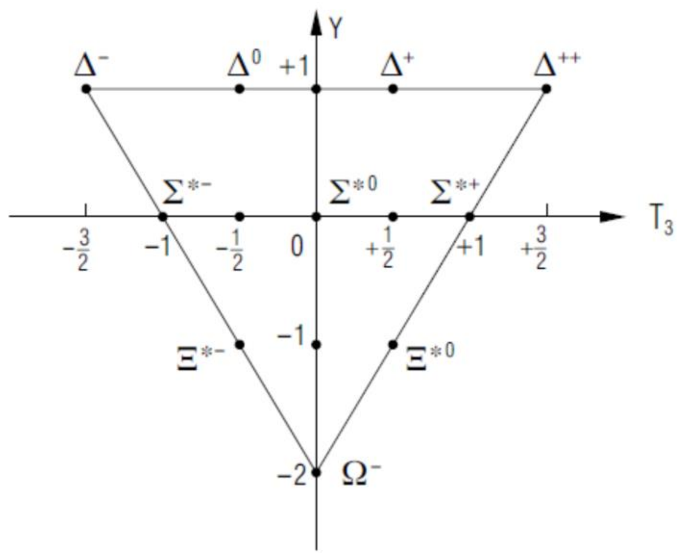
но

$$\pi \uparrow\downarrow \quad vs. \quad \rho \uparrow\uparrow$$

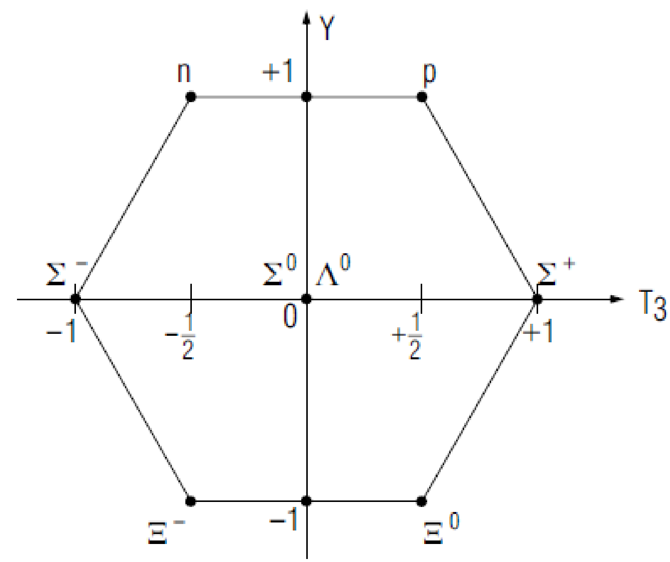
Бариони

$$B(q^1 q^2 q^3) \qquad 3 \otimes 3 \otimes 3 = 10 \oplus 8 \oplus 8 \oplus 1$$





$\oplus$

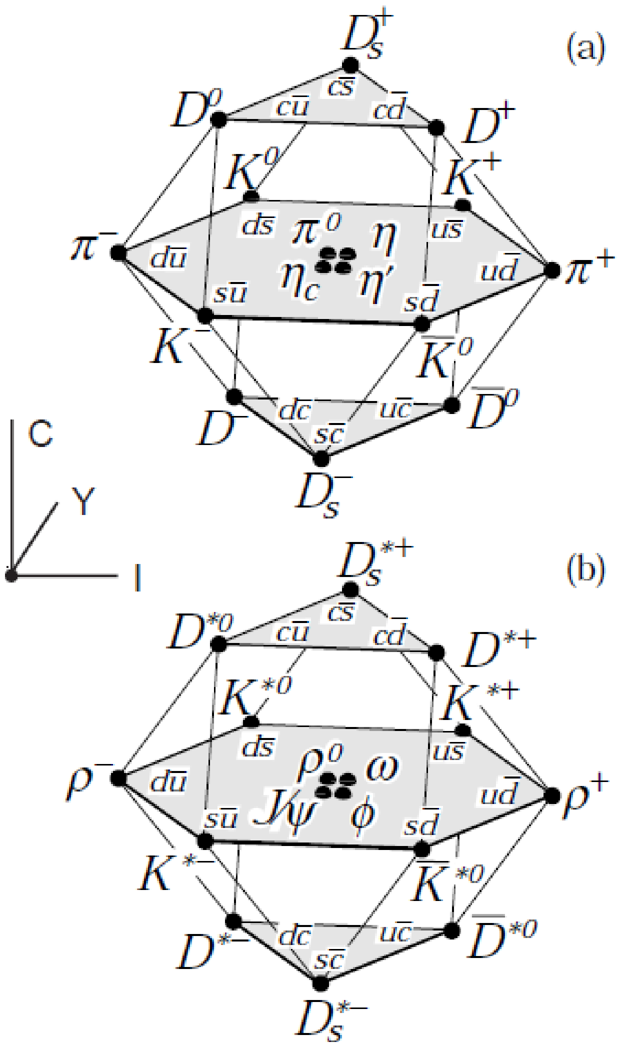


quarks:	T	particle:
uud	$1/2$	p
udd	$1/2$	n
uds	0	Λ^0
uus	1	Σ^+
uds	1	Σ^0
dds	1	Σ^-
uss	$1/2$	Ξ^0
dss	$1/2$	Ξ^-

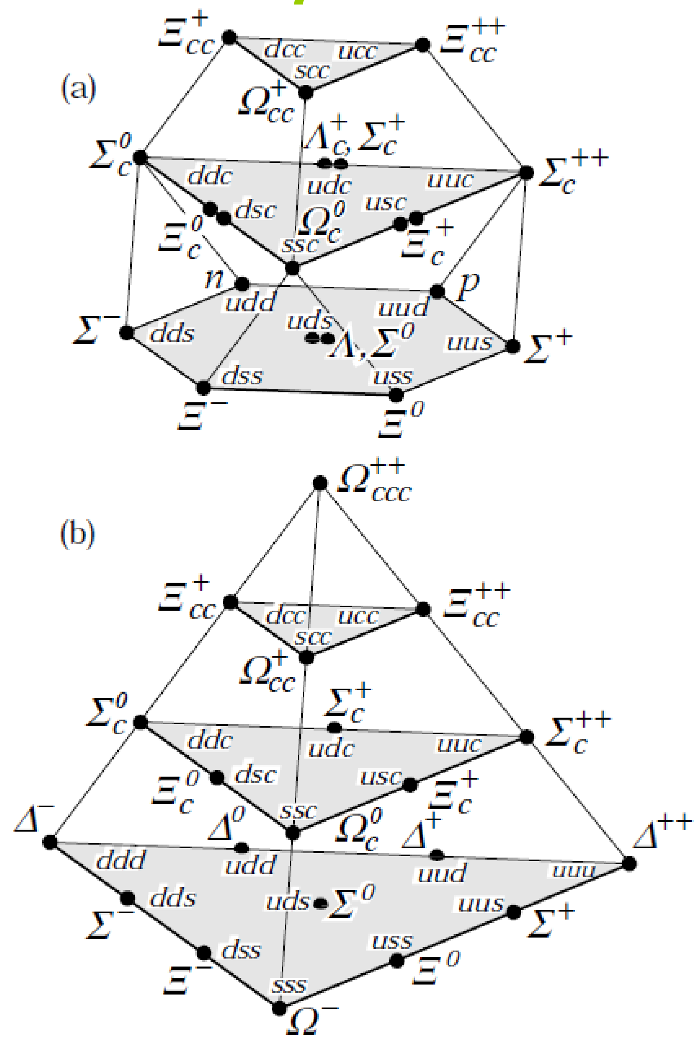
quarks:	T	particle:
uuu	$3/2$	Δ^{++}
uud	$3/2$	Δ^+
udd	$3/2$	Δ^0
ddd	$3/2$	Δ^-
uus	1	Σ^{*+}
uds	1	Σ^{*0}
dds	1	Σ^{*-}
uss	$1/2$	Ξ^{*0}
dss	$1/2$	Ξ^{*-}
sss	0	Ω^-

SU(4)

мезони



бариони



6 кварка

Property \ Quark	d	u	s	c	b	t
Q – electric charge	$-\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$	$+\frac{2}{3}$
I – isospin	$\frac{1}{2}$	$\frac{1}{2}$	0	0	0	0
I_z – isospin z-component	$-\frac{1}{2}$	$+\frac{1}{2}$	0	0	0	0
S – strangeness	0	0	-1	0	0	0
C – charm	0	0	0	$+1$	0	0
B – bottomness	0	0	0	0	-1	0
T – topness	0	0	0	0	0	$+1$

Маси на кварките

u $\quad I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

$m_u = 2.3^{+0.7}_{-0.5}$ MeV $\quad$ Charge $= \frac{2}{3}\,e$ $\quad I_z = +\frac{1}{2}$
$m_u/m_d = 0.38$–0.58

d $\quad I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

$m_d = 4.8^{+0.7}_{-0.3}$ MeV $\quad$ Charge $= -\frac{1}{3}\,e$ $\quad I_z = -\frac{1}{2}$
$m_s/m_d = 17$–22
$\overline{m} = (m_u+m_d)/2 = 3.2$–$4.4$ MeV

s $\quad I(J^P) = 0(\frac{1}{2}^+)$

$m_s = 95 \pm 5$ MeV $\quad$ Charge $= -\frac{1}{3}\,e$ $\quad$ Strangeness $= -1$
$m_s\ /\ ((m_u + m_d)/2) = 27 \pm 1$

c $\quad I(J^P) = 0(\frac{1}{2}^+)$

$m_c = 1.275 \pm 0.025$ GeV $\quad$ Charge $= \frac{2}{3}\,e$ $\quad$ Charm $= +1$

b $\quad I(J^P) = 0(\frac{1}{2}^+)$

Charge $= -\frac{1}{3}\,e$ $\quad$ Bottom $= -1$

$m_b(\overline{\mathrm{MS}}) = 4.18 \pm 0.03$ GeV
$m_b(1\mathrm{S}) = 4.65 \pm 0.03$ GeV

t $\quad I(J^P) = 0(\frac{1}{2}^+)$

Charge $= \frac{2}{3}\,e$ $\quad$ Top $= +1$

Mass (direct measurements) $m = 173.21 \pm 0.51 \pm 0.71$ GeV [a,b]
Mass ($\overline{\mathrm{MS}}$ from cross-section measurements) $m = 160^{+5}_{-4}$ GeV [a]
Mass (Pole from cross-section measurements) $m = 176.7^{+4.0}_{-3.4}$ GeV
$m_t - m_{\bar{t}} = -0.2 \pm 0.5$ GeV $\quad$ (S = 1.1)

http://pdg.lbl.gov/2014/reviews/rpp2014-rev-quark-masses.pdf