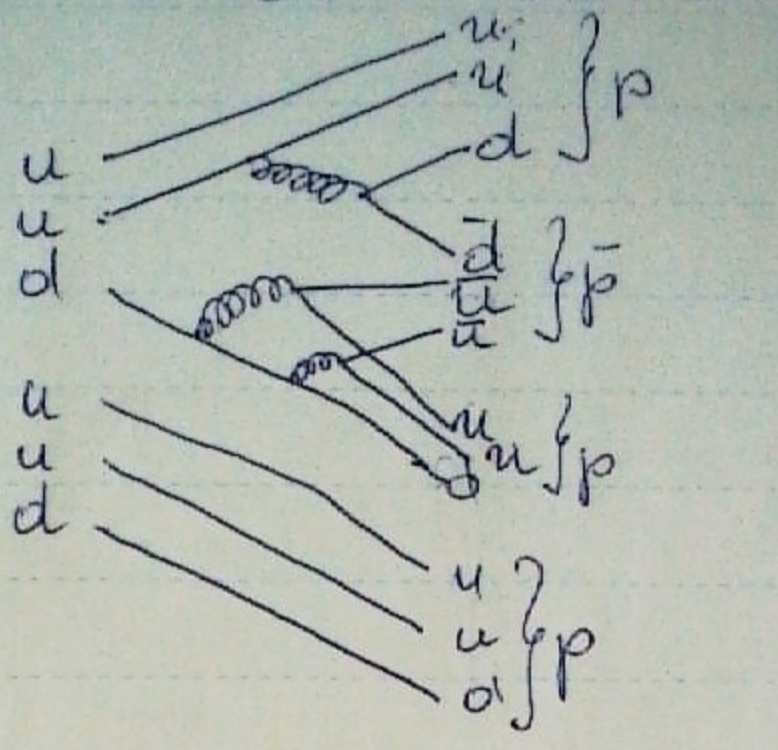
OHRANJEN B NA NIVOJU KVARKOV

$pp \to ppp\bar{p}$



KVARKI $B = +\frac{1}{3}$

ANTIKVARKI $= -\frac{1}{3}$

OHRANJEN LEPTONSKEGA ŠTEVILA

LEPTONI $L = +1$ ANTIDELCI $L = -1$ HADRONI $L = 0$

$e^+e^- \to \tau^+\tau^-$ DOVOLJEN PROCES

L: $\mp 1 + 1 = \mp 1 + 1$ ✓

$pp \to e^+e^+$ NE DOVOLJEN

L: $0+0 \neq -1-1$

B: $+1+1 \neq 0+0$

DN: $\pi^+ \to \mu^+ \nu_\mu$ DOVOLJEN?

$\nu_\mu n \to p \mu^-$

L: $+1+0 \to 0+1$ ✓

B: $0+1 \to 1+0$ ✓

$L_\mu = +1+0 \to 0+1$ ✓

$\nu_\mu n \to p e^-$

L: $1+0 \to 0+1$

L_μ: $1+0 \to 0+0$

L_e: $0+0 \to 0+1$

NE GRE EKSPERIMENT!

L_e, L_μ, L_τ : VSA TRI SO LOČENO OHRANJAJO

$\mu^+ \to e^+\gamma$ NI MOŽEN, L_μ, L_e SE NE OHRANJATA

OHRANJEN LEPTONSKEGA okusa.

DN: $\pi^0 \to e^+e^-$, $\rho \to n e^+ \nu_e$, $K^+ n \to \Sigma^+ \pi^0$, $K_p \to \Sigma^0 \pi^0$

SIMETRIJA VALOVNE FUNKCIJE

VAL. F. DVEH DELCEV (IDENTICNIH)

$$|\psi(1,2)|^2 = |\psi(2,1)|^2 \Rightarrow \psi(1,2) = \pm \psi(2,1)$$

VALOV. FUNKCIJA POSAMEZNEGA DELCA $\phi(1)$, $\phi(2)$

MOŽNI STANJI: a, b

$$\psi_S = \frac{1}{\sqrt{2}} [\phi_a(1)\phi_b(2) + \phi_b(1)\phi_a(2)] \quad \text{SIMET.}$$

$$\psi_A = \frac{1}{\sqrt{2}} [\phi_a(1)\phi_b(2) - \phi_b(1)\phi_a(2)] \quad \text{ANTISIMET.}$$

CE $a=b \Rightarrow \psi_A(1,2) = 0$, $\psi_S(1,2) \neq 0$

HADRONI V KVARKOVSKEM MODELU

BARIONI: SESTAVLJENI IZ TREH KVARKOV

Q: $+\frac{2}{3}e_0$, $-\frac{1}{3}e_0$

IZ TREH KVARKOV u, d, s : $3^3 = 27$ RAZLICNIH KOMBINACIJ

ZACNIMO S SIMETRICNIMA KOMBINACIJAMA u, d

$$\psi_{S1} = |u,u\,u\rangle \quad \psi_{S2} = |d\,d\,d\rangle$$

IZOSPIN: HEISENBERG: p IN n

ISTI DELEC Z RAZLICNO VREDNOSTJO TRETJE KOMPONENTE IZOSPINA I_3, $I_3 = +\frac{1}{2}$ ZA p

$I_3 = -\frac{1}{2}$ ZA n $\quad I_3|p\rangle = \frac{1}{2}|p\rangle \quad I_3|n\rangle = +\frac{1}{2}|n\rangle$

MOCNA INTERAKCIJA pp, pn, nn JE ENAKA

PO ANALOGIJI Z NAVADNIM SPINOM

$$\hat{I}_+ |p\rangle = 0 \quad , \quad \hat{I}_- |p\rangle = |n\rangle$$
$$\hat{I}_+ |n\rangle = |p\rangle , \quad \hat{I}_- |n\rangle = 0$$

NAMO JE TO PRI KVARKIH $u\ (+\frac{2}{3}e_0)$, $d\ (-\frac{1}{3}e_0)$

p: uud n: udd

$$I_+ |u\rangle = 0 \quad , \quad I_- |u\rangle = |d\rangle$$
$$I_+ |d\rangle = |u\rangle , \quad I_- |d\rangle = 0$$

$$\hat{I}_- |uuu\rangle = \sum_{i=1}^{3} \hat{I}_{i-} |uuu\rangle = |duu\rangle + |udu\rangle + |uud\rangle$$
$$\rightarrow \frac{1}{\sqrt{3}}(|duu\rangle + |udu\rangle + |uud\rangle) = \psi_{S3}$$

$$\hat{I}_+ |ddd\rangle \rightarrow \frac{1}{\sqrt{3}}(|udd\rangle + |dud\rangle + |ddu\rangle) = \psi_{S4}$$

ČUDNOST

$\pi^- p \rightarrow K^0 \Lambda^0$ ČUDNI DELCI NASTAJAJO V PARIH (MOČNA INTERAKCIJA)

$\Lambda^0 \rightarrow \pi^- p$ V KONČNEM STANJU NOBENEGA ČUD DELCA
$\tau \sim 10^{-10}\,s$

$\Delta^0 \rightarrow \pi^0 n \quad \tau \sim 10^{-23}\,s$

ČUDNOST - STRANGENESS S : p, n S=0, Λ^0: S=-1
KVARKI u, d: S=0, s: S=-1.
OHRANITEV ČUDNOSTI: S SE OHRANJA PRI MOČNI IN ELEKTROMAGNETNI INTER, NE OHRANJA PA SE PRI ŠIBKI.

素粒子宇宙起源研究機構

Kobayashi-Maskawa Institute for the Origin of Particles and the Universe

NADALJUJETO S TUJERBO VAL. FUNKCIJ (SIMETRIČNIH)

$u \to s$:

$|uuu\rangle \to \frac{1}{\sqrt{3}}(|suu\rangle + |usu\rangle + |uus\rangle) = \psi_{S5}$

$\frac{1}{\sqrt{3}}(|udd\rangle + |dud\rangle + |ddu\rangle) \to \frac{1}{\sqrt{3}}(|sdd\rangle + |dsd\rangle + |dds\rangle) = \psi_{S6}$

$\frac{1}{\sqrt{3}}(|duu\rangle + |udu\rangle + |uud\rangle) \to$

$\frac{1}{\sqrt{6}}(|dsu\rangle + |dus\rangle + |sdu\rangle + |uds\rangle + |sud\rangle + |usd\rangle) = \psi_{S7}$

$\frac{1}{\sqrt{3}}(|suu\rangle + |usu\rangle + |uus\rangle) \to \frac{1}{\sqrt{3}}(|ssu\rangle + |sus\rangle + |uss\rangle) = \psi_{S8}$

$\to \frac{1}{\sqrt{3}}(|dss\rangle + \cancel{|dss\rangle} + |sds\rangle + |ssd\rangle) = \psi_{S9}$

$\psi_{S8} \to |sss\rangle = \psi_{S10}$

$\Rightarrow$ 10 SIMETRIČNIH VALOVNIH FUNKCIJ

ANTISIMETRIČNA VALOVNA F 3 KVARKOV

ZAČNEM Z $|ud\rangle - |du\rangle$ ANTISIM. V.F. DVEH KVARKOV

$\psi_{A1} = \frac{1}{\sqrt{6}}[|uds\rangle - |dus\rangle + |usd\rangle - |dsu\rangle + |sud\rangle - |sdu\rangle]$

OSTANE 16 VALOVNIH FUNKCIJ ! NITI SIMETRIČNE, NITI ANTISIMETRIČNE - Z MEŠANO SIMETRIJO

PRIMER $\psi_{MA1} = \frac{1}{\sqrt{2}}[|udu\rangle - |duu\rangle]$

素粒子宇宙起源研究機構

Kobayashi-Maskawa Institute for the Origin of Particles and the Universe

MESANA SIMETRIČNA (SIMETRIČNA NA ZAMENJAVO PARIH DVEH DELCEV)

ψ_{MS1}

$\langle \psi_{MS1} | \psi_{MA1} \rangle = 0 \quad \langle \psi_{MS1} | \psi_{S3} \rangle = 0 \quad \langle \psi_{MS1} | \psi_{MS1} \rangle = 1$

$$|\psi_{MS1}\rangle = a\,|uud\rangle + b\,|udu\rangle + c\,|duu\rangle$$

$$\frac{1}{\sqrt{2}}(a\langle uud| + b\langle udu| + c\langle duu|)(|udu\rangle - |duu\rangle) = 0$$

$$\frac{1}{\sqrt{2}}(b - c) = 0 \Rightarrow b = c$$

$$0 = \frac{1}{\sqrt{3}}(a\langle uud| + b\langle udu| + c\langle duu|)(|uud\rangle + |udu\rangle + |duu\rangle)$$

$$\frac{1}{\sqrt{3}}(a + b + c) = 0 \Rightarrow a = -b - c = -2b$$

$$a^2 + b^2 + c^2 = 1 \Rightarrow 4b^2 + b^2 + b^2 = 6b^2 = 1$$

$$|\psi_{MS1}\rangle = \frac{1}{\sqrt{6}}(-2\,|uud\rangle + |udu\rangle + |duu\rangle)$$

$\Rightarrow$ 8 MESANIH ANTISIMETRIČNIH F.

8 - " - SIMETRIČNIH F.

TO JE OKUSNI DEL VALOVNE FUNKCIJE

SPINSKI DEL VALOVNE FUNKCIJE

KVARKI: SPIN $\frac{1}{2}$, 3 PROJEKCIJA $\pm\frac{1}{2}$

TRIJE KVARKI $2^3 = 8$ MOŽNOSTI od $|\uparrow\uparrow\uparrow\rangle$

DO $|\downarrow\downarrow\downarrow\rangle$

$|\uparrow\uparrow\uparrow\rangle$ SIMETRIČNA KOMBINACIJA, $J = \frac{3}{2}$

$|uuu\rangle \rightarrow |\uparrow\uparrow\uparrow\rangle \quad |ddd\rangle \rightarrow |\downarrow\downarrow\downarrow\rangle$

$\psi_{S3} \rightarrow \frac{1}{\sqrt{3}}(|\downarrow\uparrow\uparrow\rangle + |\uparrow\downarrow\uparrow\rangle + |\uparrow\uparrow\downarrow\rangle)$

$\psi_{S4} \rightarrow \frac{1}{\sqrt{3}}(|\uparrow\downarrow\downarrow\rangle + |\downarrow\uparrow\downarrow\rangle + |\downarrow\downarrow\uparrow\rangle)$

MEŠANE VALOVNE FUNKCIJE

$$\psi_{MA1} = \frac{1}{\sqrt{2}}\left[|udu\rangle - |duu\rangle\right] \longrightarrow \underbrace{\frac{1}{\sqrt{2}}\left[|\uparrow\downarrow\uparrow\rangle - |\downarrow\uparrow\uparrow\rangle\right]}$$

$$\frac{1}{\sqrt{2}}\left(|\downarrow\uparrow\rangle - |\uparrow\downarrow\rangle\right) \rightarrow J=0 \Rightarrow J=\frac{1}{2}$$

CELOTNA VALOV. FUNKCIJA IN DELEC Δ^{++}

Δ^{++}: BARION, $|uuu\rangle$ OKUS VAL. F. = SIM.

SPIN: $J=\frac{3}{2}$ SPINSKA V. F. = SIM.

$$\Psi_{\Delta^{++}} = \psi_S(\text{okus})\,\psi_S(\text{spin})\,\psi_S(\vec{r})\,\psi_A(\text{BARVA})$$

→ POTREBUJEM PROSTOSTNO STOPNJO BARVA

R RDEČA, B MODRA, G ZELENA

$$\psi_A(\text{BARVA}) = \frac{1}{\sqrt{6}}\left[|RGB\rangle - |GRB\rangle + |RBG\rangle - |GBR\rangle + |BGR\rangle - |BGR\rangle\right]$$

$$= \frac{1}{\sqrt{6}}\left[|RGB\rangle + |GBR\rangle + |BRG\rangle - |GRB\rangle + |BGR\rangle + |RBG\rangle\right]$$

VSI BARIONI: ENAKA BARVNA VAL. FUNKCIJA

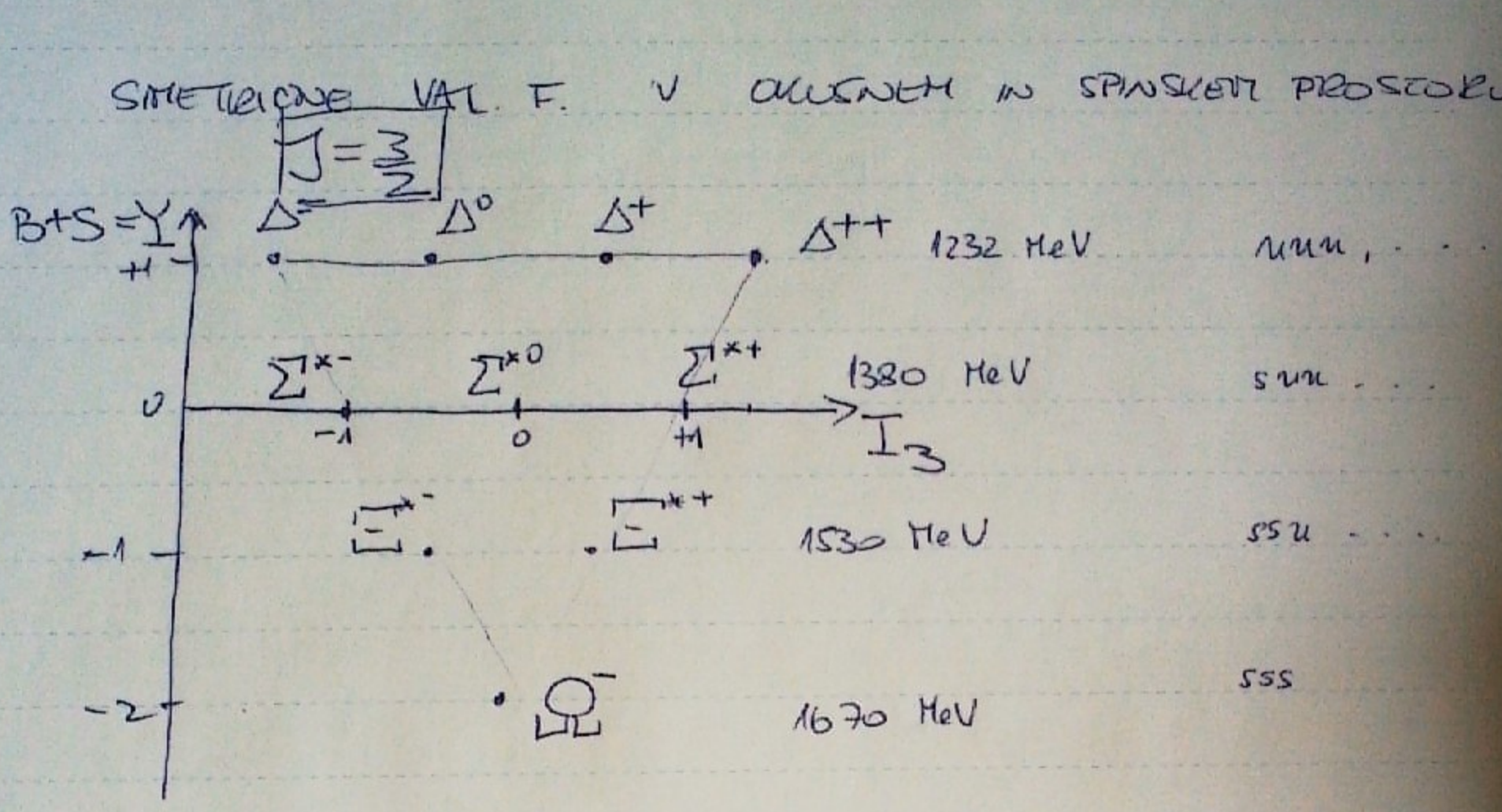
BARIONI SPIN $\frac{1}{2}$: VALOVNA F. V OKUSNEM IN SPINSKEM PROSTORU

$$\left(\psi_{MS1}(\text{okus})\,\psi_{S1}(\text{spin}) + \psi_{MA1}(\text{okus})\,\psi_{MA1}(\text{spin})\right)$$

8 VALOVNIH FUNKCIJ, SPIN $\frac{1}{2}$, SIMETRIČNE V OKUSNO-SPINSKEM PROSTORU.

KLASIFIKACIJA BARIONOV I_3, $B+S=Y$ HIPERNABOJ

SIMETRIČNE VAL. F. V ODVISNOSTI OD SPINSKEGA PROSTORA



DEKUPLET BARIONOV