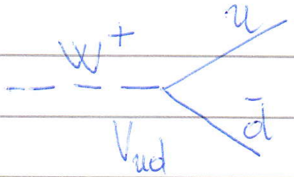
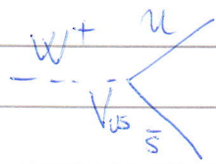
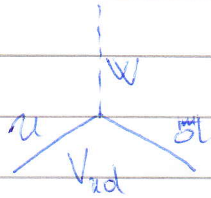
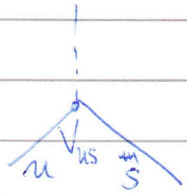
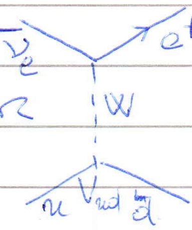




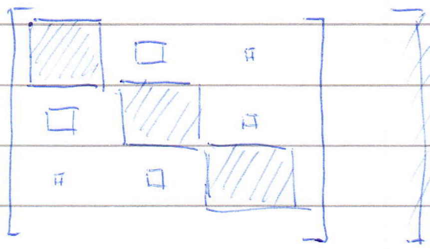


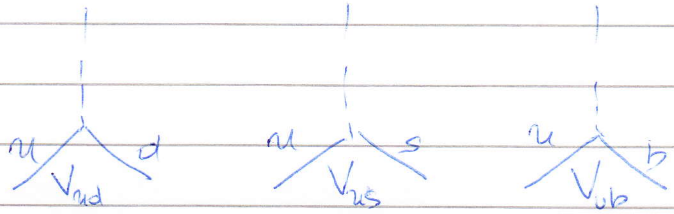


PRIMER



$$\begin{bmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{bmatrix} =$$





$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 1$$

ORTOGONALNE VRSTICE IN STOLPCI = $\boxed{\text{UNITARNA MATRIKA}}$

NA PRIMER $\quad V_{ud} V_{cd}^* + V_{us} V_{cs}^* + V_{ub} V_{cb}^* = 0$

ZA 4 KVARKE : $\begin{bmatrix} \cos\vartheta_c & \sin\vartheta_c \\ -\sin\vartheta_c & \cos\vartheta_c \end{bmatrix}$ $\quad \vartheta_c$ = CABIBBOV KOT

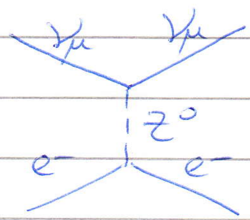
u d s c

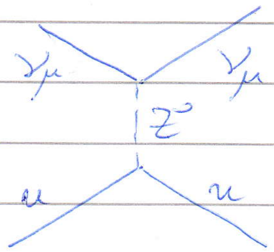
ORTOGONALNA MATRIKA $\quad \sin\vartheta_c \sim 0{,}22$

NEVTRALNI ŠIBKI TOK

NOSILEC ŠIBKE SILE Z^0

PRIMER $\quad \nu_\mu e^- \to \nu_\mu e^-$

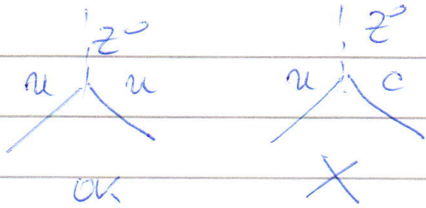




$$J_\mu^{NC} = \overline{u}_f \gamma_\mu (c_V - c_A \gamma^5) u_i$$

	ν	e, μ, τ	u, c, t	$d\, s\, b$
c_V	1	-0,03	0,19	0,34
c_A	1	$-\frac{1}{2}$	$\frac{1}{2}$	$-\frac{1}{2}$

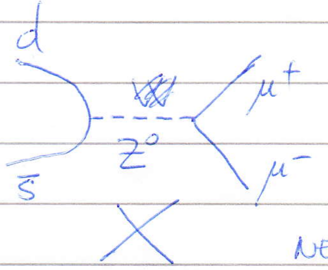
NEVTRALNI TOKOVI NE SPREMINJAJO OKUSA DELCA.



$K^0 \rightarrow \mu^+ \mu^-$

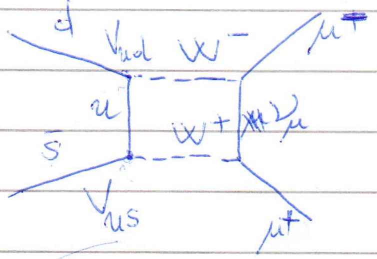
$d\bar{s}$

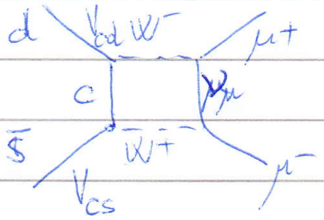
$BR(K^0 \rightarrow \mu^+\mu^-) \doteq 9 \cdot 10^{-9}$



NE GRE

ZARADI





$V_{ud} = \cos\vartheta_c \quad V_{us} = \sin\vartheta_c \quad V_{cd} = -\sin\vartheta \quad V_{cs} = \cos\vartheta_c$

$\mathcal{M}_1 \propto V_{ud} V_{us} = \cos\vartheta_c \sin\vartheta$

$\mathcal{M}_2 \propto V_{cs} V_{cd} = \cos\vartheta_c (-\sin\vartheta_c)$

$\mathcal{M} = \mathcal{M}_1 + \mathcal{M}_2 \sim 0 \Rightarrow BR(K^0 \rightarrow \mu^+\mu^-)$ ZELO MAJHEN

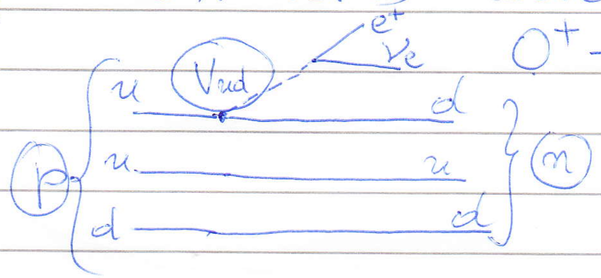
MEHANIZEM GIM

3x3 MATRIKA CKM

$$V_{\mathrm{CKM}} = \begin{pmatrix} 0.97446 \pm 0.00010 & 0.22452 \pm 0.00044 & 0.00365 \pm 0.00012 \\ 0.22438 \pm 0.00044 & 0.97359^{+0.00010}_{-0.00011} & 0.04214 \pm 0.00076 \\ 0.00896^{+0.00024}_{-0.00023} & 0.04133 \pm 0.00074 & 0.999105 \pm 0.000032 \end{pmatrix},$$

POT DO MATRIČNIH ELEMENTOV

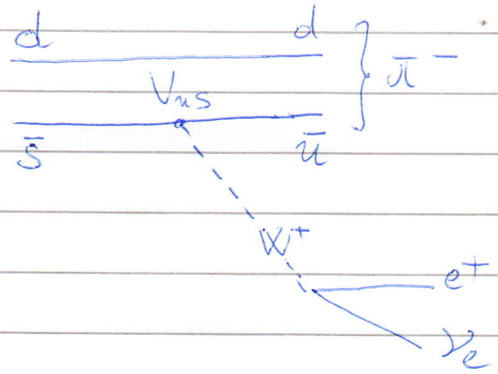
V_{ud} BETA RAZPAD (SUPERDOVOLJENI RAZPADI) $0^+ \to 0^+$



$$\frac{1}{\tau} = \frac{\Gamma}{\hbar} \propto |V_{ud}|^2$$

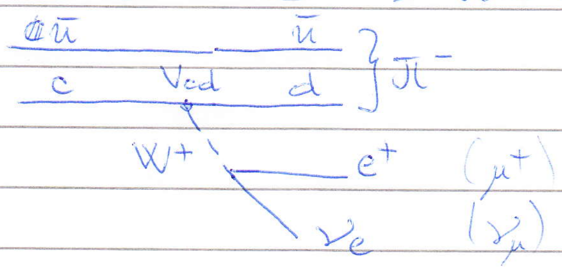
$\hookrightarrow$ IZRAČUNAM $(G_F^2)_\beta = (G_{F_\mu}^2) \cdot |V_{ud}|^2$

V_{us} RAZPAD $K^0 \to \pi^- e^+ \nu_e$



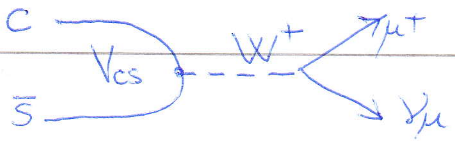
$BR \propto |V_{us}|^2$

V_{cd} RAZPAD $D^0 \to \pi e \nu_e$



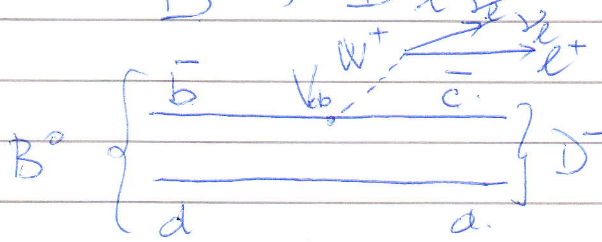
$BR \propto |V_{cd}|^2$

V_{cs} LEPTONSKI RAZPAD D_s^+ $D_s^+ \to \mu^+ \nu_\mu$



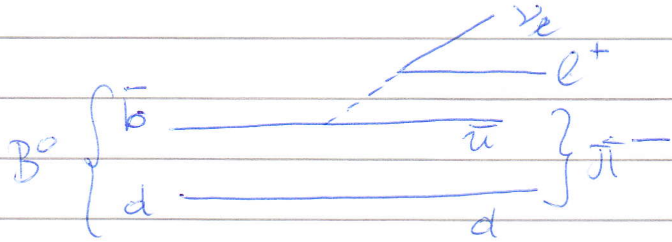
$BR \propto |V_{cs}|^2$

V_{cb} $\quad B^0 \to D^- l^+ \nu_e \quad l = e, \mu$



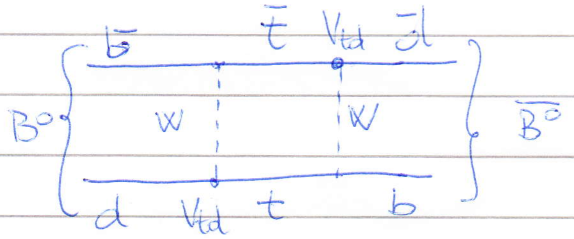
$BR \propto |V_{cb}|^2$

V_{ub} $\quad B^0 \to \pi^- l^+ \nu_e$



$BR \propto |V_{ub}|^2$

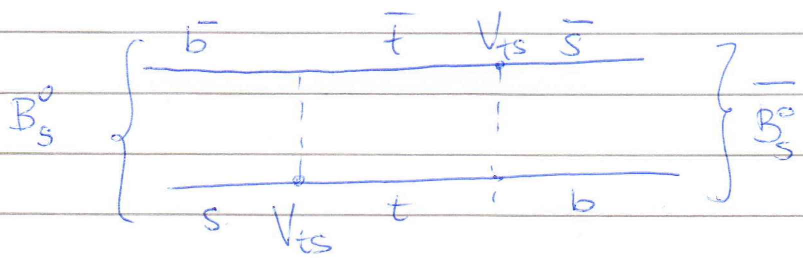
V_{td} IN V_{ts} IZ MEŠANJA MEZONOV B IN B_s



$B^0 \leftrightarrow \bar{B}^0$

MEŠANJE

FREKVENCA MEŠANJA $\propto |V_{td}|^2$



$B_s^0 \leftrightarrow \bar{B}_s^0$

FREKVENCA MEŠANJA $\propto |V_{ts}|^2$

WOLFENSTEINOVA PARAMETRIZACIJA

$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} = \begin{pmatrix} 1-\frac{\lambda^2}{2} & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\frac{\lambda^2}{2} & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + \mathcal{O}(\lambda^4)$$

$$\lambda = \sin\vartheta_c = 0.22$$

$$\lambda = 0.22453 \pm 0.00044\,, \qquad A = 0.836 \pm 0.015\,,$$
$$\bar\rho = 0.122^{+0.018}_{-0.017}\,, \qquad \bar\eta = 0.355^{+0.012}_{-0.011}\,.$$

MEŠANJE PRI NEUTRALNIH MEZONIH

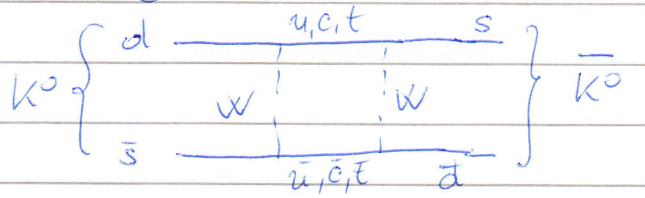
K^0, D^0, B^0, B_s^0 ← 2005 CDF FERMILAB

K^0: 50-ta

D^0: BELLE, BABAR 2007

B^0: 1987 ARGUS

MEŠANJE PRI KAONIH



$$K^0 \leftrightarrow \bar{K^0}$$

$$\psi(K^0) \neq A\, e^{\frac{iEt}{\hbar}}\, \underbrace{e^{-\frac{\Gamma t}{\hbar}}}_{=e^{-t/\tau}}$$

$$|K_1\rangle = \frac{1}{\sqrt{2}}\left(|K^0\rangle + |\bar{K^0}\rangle\right) \qquad |K_2\rangle = \frac{1}{\sqrt{2}}\left(|K^0\rangle - |\bar{K^0}\rangle\right)$$

CP PARNOST STANJ K_1 IN K_2

$$CP|K^0\rangle = |\bar{K^0}\rangle \qquad CP|\bar{K^0}\rangle = |K^0\rangle$$

$$CP|K_1\rangle = \frac{1}{\sqrt{2}}\left(|\bar{K^0}\rangle + |K^0\rangle\right) = +|K_1\rangle$$

$$CP|K_2\rangle = \frac{1}{\sqrt{2}}\left(|\bar{K^0}\rangle - |K^0\rangle\right) = -|K_2\rangle$$

RAZPADI NEVTRALNI KAONOV V PIONE

$\rightarrow 2\pi$ $\qquad$ $\rightarrow 3\pi$

$\pi^+\pi^-$ $\qquad$ $\pi^+\pi^-\pi^0$

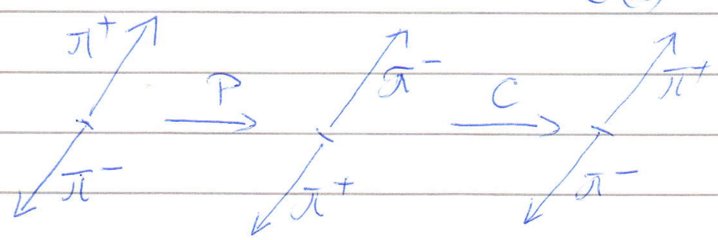
KAKŠNA JE CP PARNOST TEH KAONIH STANJ?

$P(\pi) = -1$ $\qquad$ $P(\pi^+\pi^-) = P_\pi P_\pi (-1)^l = +1$

<u>$\pi^+\pi^-$</u>

ker $l=0$

$C(\pi) = +1$ *



$CP(2\pi) = (+1)\cdot(+1) = +1$

* $C(\pi) = +1$ se vidi iz tega, ker pion π^0 razpada v 2γ $\quad \pi^0 \rightarrow \gamma\gamma$

$$CP|\pi^+\pi^-\rangle = (+1)|\pi^+\pi^-\rangle$$

$\pi^+\pi^-\pi^0$ $\qquad$ $P(\pi^+\pi^-\pi^0) = (-1)^3 = -1$

$C(\pi^+\pi^-\pi^0) = +1$

$CP(\pi^+\pi^-\pi^0) = -1$

$CP(K_1) = +1 \qquad CP(K_2) = -1$

$CP(2\pi) = +1 \qquad CP(3\pi) = -1$

$\Rightarrow$ ČE SE OHRANJA PARNOST CP $\rightarrow$

$K_1 \rightarrow 2\pi \quad , \quad K_2 \rightarrow 3\pi$

ŽIVLJENSKA DOBA K_1 IN K_2

$$d\Gamma = \frac{|M|^2}{2M_K} dQ \qquad \frac{d^3p}{(2\pi)^3}$$

$M_{K^0} \sim 0.5 \text{ GeV} \qquad M_\pi \sim 0.14 \text{ GeV}$

$2M_\pi = 0.28 \text{ GeV}$

$3M_\pi = 0.42 \text{ GeV}$

$\Rightarrow$ FAZNI PROSTOR ZA 2π RAZPAD $\gg$ 3π RAZPAD

$\tau_{K_1} \ll \tau_{K_2} \qquad \tau_{K_2} \sim 600\, \tau_{K_1}$

$0.893 \cdot 10^{-10} \qquad 0.517 \cdot 10^{-7} s$

$K_1 \sim K_S^0 \qquad K_2 \sim K_L^0$.

POSLEDICA:

$\pi^+ p \rightarrow K^0 \Lambda \qquad |K_1\rangle = \frac{1}{\sqrt{2}}(|K^0\rangle + |\bar{K}^0\rangle) \quad |K_2\rangle = \frac{1}{\sqrt{2}}(|K^0\rangle - |\bar{K}^0\rangle)$

MOČNA INT.

$$|K^0\rangle = \frac{1}{\sqrt{2}}(|K_1\rangle + |K_2\rangle)$$

K^0 RAZPADA, K_1 Z RAZ. Č. τ_{K_1} , K_2 S τ_{K_2}

$K_S^0 \qquad \tau_S \qquad K_L^0$ S τ_L

ČE POČAKAMO DOVOLJ DOLGO ($\equiv$ ČE SMO DOVOLJ DALEČ OD TARČE, KJER JE K^0 NASTAL)

$t \gg \tau_S \Rightarrow$ VSI K_S^0 RAZPADEJO, OSTANEJO

SAMO $K_L^0 \quad (K_2) = \frac{1}{\sqrt{2}}(|K^0\rangle - |\bar{K}^0\rangle)$

1964 FITCH, CRONIN (BNL)

$K^0 \longrightarrow$ DOVOLJ DALEČ OD TARČE SAMO K_L^0

RAZPADAJO $K_L^0 \to \pi^+\pi^-\pi^0$ (CP = −1)

VIDELI PA SO TUDI RAZPADE $K_L^0 \to \pi^+\pi^-$ (CP = +1)!

⇒ CP SE NE OHRANJA PRI ŠIBKI INTERAKCIJI!

SAHAROVI RAZVOJ VESOLJA:

- ZGODNJE VESOLJE — DELCI + ANTIDELCI
- DANES — DELCI

POGOJI SAHAROVA

1. ANTIDELCI SE RAZLIKUJEJO OD DELCEV ≡ KRŠENA SIMETRIJA CP (PARNOST CP SE NE OHRANJA)
2. BARIONSKO ŠTEVILO SE NE OHRANJA
3. RAZVOJ DALEČ OD RAVNOVESNEGA STANJA