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## On the expected value of CP violation in $K^\pm \rightarrow \pi^\pm \pi^\pm \pi^\mp$ decays.

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Study of direct CP in  $K^\pm \rightarrow 3\pi$  decays will allow to understand better a nature of CP violation.

An existence of direct CP in  $K_L \rightarrow 2\pi$  decays predicted by SM and characterized by parameter  $\epsilon'$  is established:

$$\frac{\epsilon'}{\epsilon} = (1.66 \pm 0.16) 10^{-3}$$

What is expected for  $K^\pm \rightarrow \pi^\pm \pi^\pm \pi^\mp$  decays?

In particular, for CP-odd quantity

$$R_g = \frac{g^+ - g^-}{g^+ + g^-}$$

where the slope parameters  $g^\pm$  are defined by the relation

$$\left| M(K^\pm \rightarrow \pi^\pm(p_1) \pi^\pm(p_2) \pi^\mp(p_3)) \right|^2 \sim 1 + g^\pm \frac{s_3 - s_0}{m_\pi^2} + \dots$$

$$s_3 = (K - p_3)^2, \quad s_0 = \frac{1}{3} m_K^2 + m_\pi^2$$

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Comparison of the expected magnitude of  $R_g$  with the observed value will clear up at least two questions:

- 1) is the K-M phase the only source of CP
- 2) how essential role of EW penguin contribution to CP in  $K^0 \rightarrow 2\pi$  and  $K^\pm \rightarrow 3\pi$  decays.

The large uncertainty of the pure theoretical predictions for  $\epsilon'/\epsilon$ , characterised by the results

$$\epsilon'/\epsilon = (17^{+14}_{-10}) 10^{-4} \text{ Bertolini et al' 98}$$

$$\epsilon'/\epsilon = (1.5 \div 31.6) 10^{-4} \text{ Hambye et al' 2000 ,}$$

do not allow to exclude the contributions of the sources of CP beyond K-M phase.

As for the second question, it is known that  $\epsilon'$  crucially depends on relative strength of QCD and EW penguin contributions, and what's more, the last one decreases  $\epsilon'$  substantially.

Is it so for CP in  $K^\pm \rightarrow 3\pi$  decays?

To diminish the uncertainties appearing in pure theoretical calculations of the ingredients of the theory, calculating  $R_g$ , we shall use the magnitudes of the parameters of the theory extracted from data on  $K_L \rightarrow 2\pi$  decays.

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## 2. The scheme of calculations

A theory of  $\Delta S=1$  non-leptonic decays is based on the effective lagrangian (Shifman, Vainshtein, Zakharov'77)

$$L(\Delta S=1) = \sqrt{2} G_F \sin \theta_c \cos \theta_c \sum c_i O_i$$

where

$$O_1 = \bar{s}_L \gamma_\mu d_L \cdot \bar{u}_L \gamma_\mu u_L - \bar{s}_L \gamma_\mu u_L \cdot \bar{u}_L \gamma_\mu d_L \quad (\{8_f\}, \Delta I=\frac{1}{2})$$

$$\begin{aligned} O_2 = & \bar{s}_L \gamma_\mu d_L \cdot \bar{u}_L \gamma_\mu u_L + \bar{s}_L \gamma_\mu u_L \cdot \bar{u}_L \gamma_\mu d_L + \\ & + 2 \bar{s}_L \gamma_\mu d_L \cdot \bar{d}_L \gamma_\mu d_L + 2 \bar{s}_L \gamma_\mu d_L \cdot \bar{s}_L \gamma_\mu s_L \end{aligned} \quad (\{8_d\}, \Delta I=\frac{1}{2})$$

$$\begin{aligned} O_3 = & \bar{s}_L \gamma_\mu d_L \cdot \bar{u}_L \gamma_\mu u_L + \bar{s}_L \gamma_\mu u_L \cdot \bar{u}_L \gamma_\mu d_L + \\ & + 2 \bar{s}_L \gamma_\mu d_L \cdot \bar{d}_L \gamma_\mu d_L - 3 \bar{s}_L \gamma_\mu d_L \cdot \bar{s}_L \gamma_\mu s_L \end{aligned} \quad (\{27\}, \Delta I=\frac{1}{2})$$

$$\begin{aligned} O_4 = & \bar{s}_L \gamma_\mu d_L \cdot \bar{u}_L \gamma_\mu u_L + \bar{s}_L \gamma_\mu u_L \cdot \bar{u}_L \gamma_\mu d_L - \\ = & - \bar{s}_L \gamma_\mu d_L \cdot \bar{d}_L \gamma_\mu d_L \end{aligned} \quad (\{27\}, \underline{\Delta I=\frac{3}{2}})$$

$$\left. \begin{aligned} O_5 = & \bar{s}_L \gamma_\mu \lambda^a d_L \left( \sum_{q=u,d,s} \bar{q}_R \gamma_\mu \lambda^a q_R \right) \\ O_6 = & \bar{s}_L \gamma_\mu d_L \left( \sum_{q=u,d,s} \bar{q}_R \gamma_\mu q_R \right) \end{aligned} \right\} \Delta I=\frac{1}{2}$$

QCD "penguin"

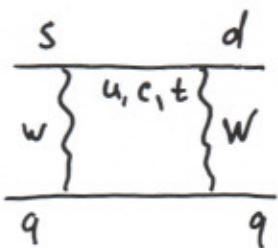
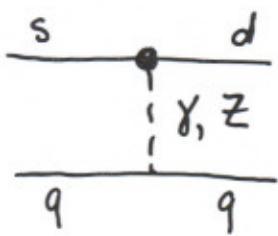
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dressed by gluons

This set is sufficient for calculation of the CP even parts of the amplitudes under consideration.

To calculate the CP-odd parts, it is necessary to add the so-called electro-weak contributions originated by the operators  $O_7, O_8$ :

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$$O_7 = \frac{3}{2} \bar{s} \gamma_\mu (1 + \gamma_5) d \left[ \frac{2}{3} \bar{u} \gamma_\mu (1 - \gamma_5) u - \frac{1}{3} \bar{d} \gamma_\mu (1 - \gamma_5) d - \frac{1}{3} \bar{s} \gamma_\mu (1 - \gamma_5) s \right]$$

$$\Delta I = \frac{1}{2}, \frac{3}{2}$$

$$O_8 = -12 \sum_{q=u,d,s} e_q (\bar{s}_L q_R) (\bar{q}_R d_L), \quad e_q = \left( \frac{2}{3}, -\frac{1}{3}, -\frac{1}{3} \right)$$

Coefficients  $c_{5-8}$  have the imaginary parts necessary for CP.

Using the Fierz reordering transformations in spinor and color spaces

$$O_5 = -\frac{8}{9} \bar{s} (1 - \gamma_5) q \cdot \bar{q} (1 + \gamma_5) d; \quad O_6 = \frac{3}{16} O_5$$

$$O_7 = -\bar{s} (1 - \gamma_5) u \cdot \bar{u} (1 + \gamma_5) d - \frac{3}{8} O_5;$$

$$O_8 = 3 O_7$$

Bosonization of these operators

Bardeen, Buras, Gera  
'87

$$\bar{q}_j (1 + \gamma_5) q_k = -\frac{1}{\sqrt{2}} F_{\pi} r (U - \frac{1}{\Lambda^2} \partial^2 U)_{kj}$$

$$r = 2m_\pi^2 / (m_u + m_d), \quad \Lambda \approx 1 \text{ GeV}$$

## Nonlinear realization of chiral symmetry

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$$U = \frac{F_\pi}{\sqrt{2}} \left( 1 + \frac{i\sqrt{2}\hat{\pi}}{F_\pi} - \frac{\hat{\pi}^2}{F_\pi^2} + a_3 \left( \frac{i\hat{\pi}}{\sqrt{2}F_\pi} \right)^3 + 2(a_3-1) \left( \frac{i\hat{\pi}}{\sqrt{2}F_\pi} \right)^4 + \dots \right)$$

$$UU^+ = 1 \cdot \frac{F_\pi^2}{2}$$

For this reason

$$O_5 \sim$$

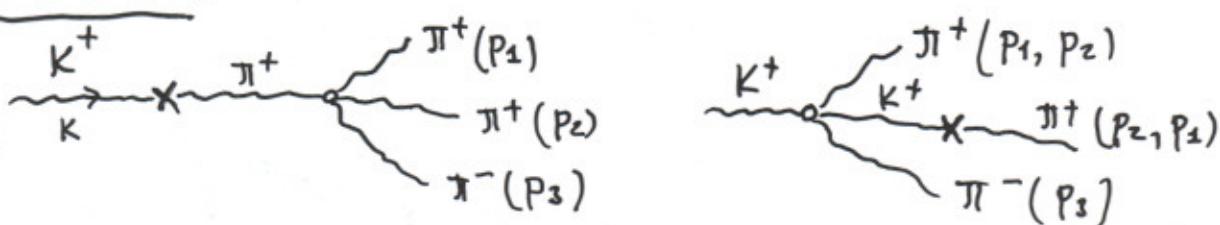
$$\hat{\pi} = \begin{pmatrix} \frac{\pi_0}{\sqrt{3}} + \frac{\pi_8}{\sqrt{6}} + \frac{\pi_3}{\sqrt{2}}, & \pi^+, & K^+ \\ \pi^-, & \frac{\pi_0}{\sqrt{3}} + \frac{\pi_8}{\sqrt{6}} - \frac{\pi_3}{\sqrt{2}}, & K^0 \\ K^-, & \bar{K}^0, & \frac{\pi_0}{\sqrt{3}} - \frac{2\pi_8}{\sqrt{6}} \end{pmatrix}$$

$$\sim \underbrace{\left( U^+ U \right)_{23}}_{=0} - \frac{1}{\Lambda^2} \underbrace{\left( U^+ \partial^2 U + \partial^2 U^+ U \right)_{23}}_{\sim p^2/\Lambda^2}$$

But

$$O_7 = - U_{21} U_{13}^+ + (\text{terms of order } \partial^2 U \cdot U^+ \dots)$$

$$\text{For } K^+ \rightarrow \pi^+ \pi^+ \pi^- : \quad = - \frac{F_\pi^2 r^2}{2} \left\{ \pi^- K^+ + \dots - \frac{i}{\sqrt{2}F_\pi} \pi^+ \pi^- K^0 + \dots \right\} + \dots$$



$$\frac{\text{Const}}{m_K^2 - m_\pi^2} \cdot \left[ \frac{s_1 + s_2 - 2\mu^2}{F_\pi^2} - \frac{(s_1 + s_2 - m_K^2 - \mu^2)}{F_\pi^2} \right] = - \frac{r^2}{2}.$$

$$\mu^2 = m_\pi^2 ; \quad s_1 = (K-p_1)^2 ; \quad s_2 = (K-p_2)^2$$

Though  $C_7 \sim \text{them } C_5$ , but the contribution of  $C_7 O_7$  is enhanced by absence of  $\Delta I = \frac{3}{2}$  suppression and by factor  $\Lambda^2/m_K^2 \approx 4$ !

$$\Delta L^{\text{mass}} =$$

To page ⑥  
(d)

$$-m_\pi^2 \pi^+ \pi^- - m_K^2 K^+ K^- - \frac{F_\pi^2 r^2}{2} (\gamma^* K^+ \pi^- + \gamma^* K^- \pi^+)$$

$$\gamma = \sqrt{2} G_F \sin \theta_c \cos \theta_c \cdot c_7$$

Feinberg, Kabir, Weinberg 1959

$$\begin{aligned} \pi^- &\rightarrow \pi^- + \beta K^- & K^+ &\rightarrow K^+ - \beta \pi^+ \\ \pi^+ &\rightarrow \pi^+ + \beta^* K^+ & K^- &\rightarrow K^- - \beta^* \pi^- \end{aligned} \quad \beta = \gamma^* \frac{F_\pi^2 r^2}{2(m_K^2 - m_\pi^2)}$$

These transformations remove the non-diagonal terms from  $\Delta L^{\text{mass}}$ .

But the effective lagrangian of strong inter. generates the sum of the amplitudes

$$\begin{aligned} &\langle \pi^+(p_1) \pi^+(p_2) \pi^-(p_3) | \pi^+(k) \rangle + \langle K^+(p_1) \pi^+(p_2) \pi^-(p_3) | K^+(k) \rangle \\ &\quad + \langle K^+(p_1) \pi^+(p_2) \pi^-(p_3) | K^+(k) \rangle \end{aligned}$$

that after the above transformations generates the amplitude

$$\langle \pi^+(p_1) \pi^+(p_2) \pi^-(p_3) | O_7 | K^+(k) \rangle =$$

$$= -\frac{\beta}{\gamma^*} \left[ \frac{s_1 + s_2 - 2m_\pi^2}{F_\pi^2} - \frac{s_1 + s_2 - m_K^2 - m_\pi^2}{F_\pi^2} \right] = -\frac{r^2}{2} .$$

Other operators are bosonized using

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$$\bar{q}_j \gamma_\mu (1 + \gamma_5) q_k = i \left[ \partial_\mu U \cdot D^+ - U \partial_\mu D^+ - \frac{e F_\pi}{\sqrt{2} \Lambda^2} \left( m \partial_\mu \bar{U}^+ - \partial_\mu U m \right) \right]_{kj}$$

Some information on the magnitudes of  
 $c_i$

can be extracted from  $K \rightarrow 2\pi$  decays.

$$M(K^0 \rightarrow \pi^+ \pi^-) = A_0 e^{i\delta_0} - A_2 e^{-i\delta_2}$$

$$M(K^0 \rightarrow \pi^0 \pi^0) = A_0 e^{i\delta_0} + 2A_2 e^{i\delta_2}$$

$$M(K^+ \rightarrow \pi^+ \pi^0) = -\frac{3}{2} A_2 e^{i\delta_2}$$

where

$$A_0 = G_F F_\pi \sin \theta_c \cos \theta_c \frac{m_K^2 - m_\pi^2}{\sqrt{2}} \left[ c_1 - c_2 - c_3 + \frac{32}{9} \beta \left( \text{Re } \tilde{c}_5 + i \text{Im } \tilde{c}_5 \right) \right],$$

$$A_2 = G_F F_\pi \sin \theta_c \cos \theta_c \frac{m_K^2 - m_\pi^2}{\sqrt{2}} \left[ c_4 + i \frac{2}{3} \beta \frac{\Lambda^2}{m_K^2 - m_\pi^2} \text{Im } \tilde{c}_7 \right]$$

$$\tilde{c}_5 = c_5 + \frac{3}{16} c_6 ; \quad \tilde{c}_7 = c_7 + 3 c_8$$

$$\beta = \frac{2 m_\pi^4}{\Lambda^2 (m_u + m_d)^2},$$

Contributions of  $\tilde{c}_7 \theta_7$  into  $\text{Re } A_0$  and  $\text{Im } A_0$  are neglected.

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From data on  $K \rightarrow 2\pi$  decays

$$C_4 = 0.328 ; \quad C_1 - C_2 - C_3 + \frac{32}{g} \beta \operatorname{Re} \tilde{c}_5 = -10.13$$

$$\text{At } C_1 - C_2 - C_3 = -2.89 \quad (\text{SVZ, Okun})$$

$$\frac{32}{g} \beta \operatorname{Re} \tilde{c}_5 = -7.24$$

Using the general relation

$$\varepsilon' = i e^{i(\delta_2 - \delta_0)} \left[ -\frac{\operatorname{Im} A_0}{\operatorname{Re} A_0} + \frac{\operatorname{Im} A_2}{\operatorname{Re} A_2} \right] \left| \frac{A_2}{A_0} \right|$$

and  $(\varepsilon')^{\text{exp}} = (3.78 \pm 0.38) 10^{-6}$  we obtain

$$-\frac{\operatorname{Im} \tilde{c}_5}{\operatorname{Re} \tilde{c}_5} \left( 1 - \Omega_{\gamma+\gamma'} + 24.36 \frac{\operatorname{Im} \tilde{c}_7}{\operatorname{Im} \tilde{c}_5} \right) = (1.63 \pm 0.16) 10^{-4}$$

where  $\Omega_{\gamma+\gamma'}$  takes into account the effects of

$K^0 \rightarrow \pi^0 \gamma (\gamma') \rightarrow \pi^0 \pi^0$  transitions.

Introducing the notations

$$-\frac{\operatorname{Im} \tilde{c}_5}{\operatorname{Re} \tilde{c}_5} = x \frac{\operatorname{Im} \lambda_t}{s_1}, \quad \frac{24.36}{1 - \Omega_{\gamma+\gamma'}} \cdot \frac{\operatorname{Im} \tilde{c}_7}{\operatorname{Im} \tilde{c}_5} = -y$$

and using

$$\operatorname{Im} \lambda_t / s_1 \equiv s_2 s_3 \sin \delta = (5.38 \pm 0.90) 10^{-4}$$

Al; London 2001

we obtain for  $\Omega_{\gamma+\gamma'} = 0.25 \pm 0.08$

$$x(1-y) = 0.40 (1 \pm 0.22)$$

In terms of notations used by Bertolini et al and Buras et al

$$y = \frac{\Pi_2}{\omega} / \Pi_0 (1 - \Sigma_{q+g})$$

According Bertolini et al' 2001  $y \approx 0.3$  But  $\frac{e'}{e} = 1.3 \left( \frac{e'}{e} \right)^{ex}$   
and hence  $x = 0.57 \pm 0.12$ .

Hambye et al' 2003 give  $y \approx 0.5$   
 $x = 0.80 \pm 0.18$

From Donoghue, Golovich' 2000  $x = 0.71 \pm 0.27$

The considerable bigger  $x$  were obtained previously:  $x \approx 2$  Bertolini et al' 95

$x \approx 3$  Buras et al' 93

$x \approx 5.5$  Bertolini et al' 95

We shall see that observation of CP-odd effects in  $K^\pm \rightarrow \eta^\pm \pi^\pm \pi^\mp$  decays will allow to determine the real value of EWP contribution.

3. Decay  $K^\pm \rightarrow \pi^\pm \pi^\pm \pi^\mp$

Neglecting CP-odd part and using  $\{\xi=0; p^2\}$  approximation

$$M(K^+(k) \rightarrow \pi^+(p_1) \pi^+(p_2) \pi^-(p_3)) = \frac{6_F \sin \theta_c \cos \theta_c}{2\sqrt{2}} \left\{ [c_1 - c_2 - c_3 - c_4 + \right. \\ \left. + \frac{32}{9} \beta \tilde{c}_5] \left( \frac{2}{3} m_K^2 + s_0 - s_3 \right) + 9 c_4 (s_0 - s_3) \right\};$$

$$M(K^+(k) \rightarrow \pi^0(p_1) \pi^0(p_2) \pi^+(p_3)) = \frac{6_F \sin \theta_c \cos \theta_c}{2\sqrt{2}} \left\{ [c_1 - c_2 - c_3 - c_4 + \right. \\ \left. + \frac{32}{9} \beta \tilde{c}_5] (s_3 - m_\pi^2) + \frac{9}{2} c_4 (s_0 - s_3) \right\};$$

where  $s_i = (k - p_i)^2$  and  $s_0 = \frac{1}{3} m_K^2 + m_\pi^2$ .

It is not difficult to check that these expressions can be rewritten in the form, obtained by methods of current algebra and soft-pion techniques (Vainshtein, Zakharov'70)

$$M(K^+ \rightarrow \pi^+ \pi^+ \pi^- (p_3)) = \frac{i}{3 F_\pi} M(K_1^0 \rightarrow \pi^+ \pi^-) [1 + \tilde{y} + 6 \zeta \tilde{y}]$$

$$M(K^+ \rightarrow \pi^0 \pi^0 \pi^+ (p_3)) = \frac{i}{6 F_\pi} M(K_1^0 \rightarrow \pi^+ \pi^-) [1 - 2 \tilde{y} + 6 \zeta \tilde{y}]$$

where

$$\tilde{y} = \frac{3 E_3}{m_K} - 1; \quad \zeta = - \frac{M(K_1^0 \pi^0 \pi^+)}{M(K_1^0 \pi^+ \pi^-)} = \frac{3 c_4}{2(c_1 - c_2 - c_3 - c_4 + \frac{32}{9} c_5 \beta)}$$

Taking into account the CP-odd contribution produced by  $\text{Im} \tilde{c}_5, \tilde{c}_7$  we obtain

$$M(K^+ \rightarrow \pi^+ \pi^+ \pi^- (p_3)) = k [1 + i a_{KM} + \frac{1}{2} g Y (1 + i b_{KM})]$$

where  $k = \frac{G_F \sin \theta_c \cos \theta_c \cdot \frac{2}{3} m_K^2 c_0}{2 \sqrt{2}}$

$$a_{KM} = \left[ \frac{32}{9} \beta \text{Im} \tilde{c}_5 + 4 \beta \text{Im} \tilde{c}_7 \left( \frac{3 \Lambda^2}{2 m_K^2} + \frac{2}{2R-1} \right) \right] / c_0$$

$$b_{KM} = \left[ \frac{32}{9} \beta \text{Im} \tilde{c}_5 + 4 \beta \text{Im} \tilde{c}_7 \cdot \frac{2}{2R-1} \right] / (c_0 + 9 c_4)$$

$$g = -\frac{3 m_\pi^2}{2 m_K^2} \cdot \frac{c_0 + 9 c_4}{c_0}$$

$$c_0 = c_1 - c_2 - c_3 - c_4 + \frac{32}{9} \beta \text{Re} \tilde{c}_5 = -10.46$$

Important point



As the field  $K^+$  is the complex one and its phase is arbitrary, we can replace  $K^+$  by  $K^+ \cdot \frac{1 + i a_{KM}}{\sqrt{1 + a_{KM}^2}}$

Then

$$M(K^+ \rightarrow \pi^+ \pi^+ \pi^- (p_3)) = k [1 + \frac{1}{2} g Y (1 - i (b_{KM} - a_{KM}))]$$

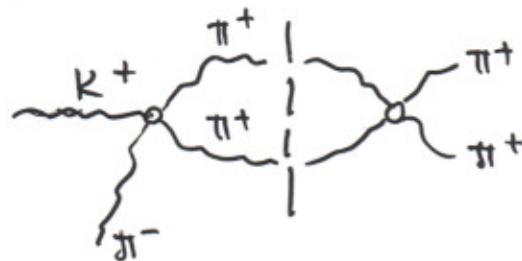
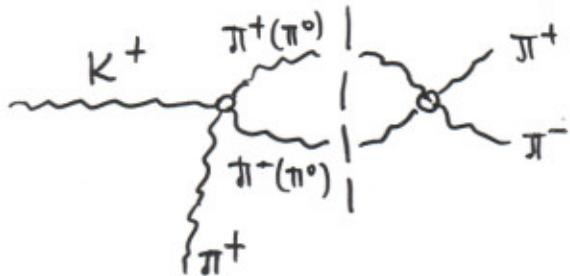
Though this expression contains the imaginary CP-odd part, it does not lead to observable CP effects. To become observable, this part must interfere with CP-even imaginary part arising due to rescattering of the final pions.

(11a)

Then

$$M(K^+ \rightarrow \pi^+ \pi^+ \pi^-) = k \left[ 1 + i a \underset{\text{CP-even}}{\uparrow} + \frac{1}{2} g \sqrt{(1 + i b \underset{\text{CP-even}}{\uparrow} - i \underbrace{(b_{KM} - a_{KM})}_{\text{CP-odd}})} \right]$$

The CP-even imaginary part can be found calculating the diagrams



Using

$$M(\pi^+(r_2)\pi^-(r_3) \rightarrow \pi^+(p_2)\pi^-(p_3)) = \frac{1}{F_\pi^2} [(p_2+p_3)^2 + (r_2-p_2)^2 - \mu^2]$$

$$M(\pi^0(r_2)\pi^0(r_3) \rightarrow \pi^+(p_2)\pi^-(p_3)) = \frac{1}{F_\pi^2} [(p_2+p_3)^2 - \mu^2]$$

$$M(\pi^+(r_1)\pi^+(r_2) \rightarrow \pi^+(p_1)\pi^+(p_2)) = \frac{1}{F_\pi^2} [(r_1 p_1)^2 + (r_1 - p_2)^2 - 2\mu^2]$$

we find

$$\boxed{\alpha = 0.12065 ; \beta = 0.714}$$

The slope parameters  $g^\pm$  are defined by the relations:

$$|M(K^\pm(k) \rightarrow \pi^\pm(p_1)\pi^\pm(p_2)\pi^\mp(p_3))|^2 \sim 1 + g^\pm Y + h^\pm Y^2 + k^\pm X^2$$

where  $Y = \frac{s_3 - s_0}{m_\pi^2} ; X = \frac{s_1 - s_2}{m_\pi^2} ; s_i = (k - p_i)^2$

Therefore

$$|M(K^+ \rightarrow \pi^+\pi^+\pi^-(p_3))|^2 \sim 1 + \frac{g}{1+\alpha^2} Y (1 + \alpha\beta + \alpha(\beta_{K\pi} - \alpha_{K\pi}))$$

$$|M(K^- \rightarrow \pi^-\pi^-\pi^+(p_2))|^2 \sim 1 + \frac{g}{1+\alpha^2} Y (1 + \alpha\beta - \alpha(\beta_{K\pi} - \alpha_{K\pi}))$$

$$R_g = \left\{ \frac{g^+ - g^-}{g^+ + g^-} = + \frac{\alpha(\beta_{K\pi} - \alpha_{K\pi})}{1 + \alpha\beta} \right\}$$

At the fixed above parameters and  $\omega_{q+q_1} = 0.25$

(13)

$$(R_g)_{p^2 \text{ appr.}} = 0.030 \frac{\text{Im } \tilde{c}_s}{\text{Re } \tilde{c}_s} \left( 1 - 14.9 \frac{\text{Im } \tilde{c}_7}{\text{Im } \tilde{c}_s} \right) = \\ = - (2.44 \pm 0.44) 10^{-5} x \left( 1 - \frac{0.13 \pm 0.03}{x} \right)$$

At  $x \approx 1$  this result is larger than obtained by L. Maiani and N. Paver "The second DAFNE Physics Handbook"

$$R_g = -(0.23 \pm 0.06) 10^{-5}$$

### The role of the $p^4$ corrections

These corrections together with the ones arising due to mixing between  $\bar{q}q$  and  $(G_{\mu\nu}^a)^2$  states can be calculated using the linear  $\Sigma$ -model elaborated previously (E. Sh'93 Nucl. Phys B 409, 87, 1993)

$$\begin{array}{l|l} a(\xi = -0.225; p^2 + p^4) = 0.16265 & a(\xi = 0; p^2) = 0.1206 \\ b(\xi = -0.225; p^2 + p^4) = 0.762 & b(\xi = 0; p^2) = 0.714 \end{array}$$

$$(R_g)_{(\xi = -0.225; p^2 + p^4)} = 0.039 \frac{\text{Im } \tilde{c}_s}{\text{Re } \tilde{c}_s} \left( 1 - 11.95 \frac{\text{Im } \tilde{c}_7}{\text{Im } \tilde{c}_s} \right) = \\ = - (3.0 \pm 0.5) 10^{-5} x \left( 1 - \frac{0.11 \pm 0.025}{x} \right)$$

This result is by 23% larger than that calculated to the leading approximation

It should be mentioned that the CP-even part of m.e. "a" can be determined using the experimental data on  $\delta_0$ .

According to definition

$$M(K^\pm \rightarrow \pi^\pm \pi^\pm \pi^\mp) \sim 1 + \frac{1}{2} g^{(\pm)} \frac{(-s_0 + s_3)}{m^2_\pi} + \dots + i\alpha$$

$\alpha \approx \tan \delta_0(s_0)$ , the other phase shifts are small:

$$\delta_0^2(s_0) < 1.8^\circ ; \quad \delta_1^1 < 0.3^\circ$$

From data on  $K_{e\mu}$  decay

$$\delta_0^0(s_0) = (7.50 \pm 2.85)^\circ \Rightarrow \alpha = 0.13 \pm 0.05 \quad \text{Rosselet et al'77}$$

$$\delta_0^0(s_0) = (8.4 \pm 1.0)^\circ \Rightarrow \alpha = 0.148 \pm 0.018 \quad \text{Pislak et al'93}$$

## Conclusion

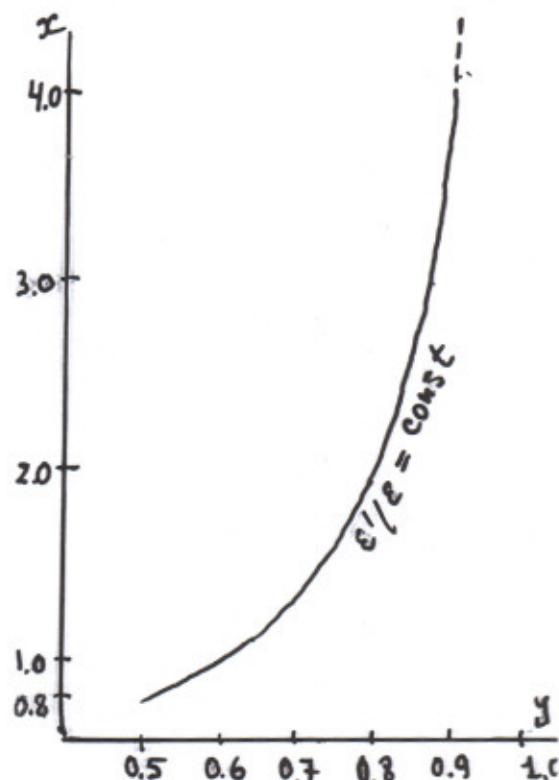
(15)

1. The expected value of  $R_g$  depends on relative strength of QCD and EW penguin contributions to CP violation, characterized by  $x$  and  $y$ , respectively.

2. This relative strength can not be fixed by value of  $\epsilon'/\epsilon$  in view of relation

$$\epsilon'/\epsilon \sim x(1-y) = 0.40 (1 \pm 0.22)$$

according to which  $\epsilon'/\epsilon$  could be the same for  $x=0.8$  and  $x=4.0$



3. Measurement of  $R_g$  in  $K^\pm \rightarrow \pi^\pm \pi^\pm \eta^\mp$  decays will allow to resolve the question on true role of EWP in direct CP violation. For this decay

$$R_g \sim x(1 + 0.46 y)$$

It gives  $R_g(x=4.0) / R_g(x=0.8) = 5.6$