DAΦNE'2004

On expected value of CP effects in decay of charged Kaons into 3 pions.

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Study of direct $\not{CP}$ in $K^\pm \to 3\pi$ decays will allow to understand better a nature of CP violation.

An existance of direct $\not{CP}$ in $K_L \to 2\pi$ decays predicted by SM and characterized by parameter ε' is established:

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

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

In particular, for CP-odd quantity

$$R_g = (g^+ - g^-)/(g^+ + g^-),$$

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

$$|M(K^\pm(k) \to \pi^\pm(p_1)\, \pi^\pm(p_2)\, \pi^\mp(p_3)|^2 \sim 1 + g^\pm \frac{s_3 - s_0}{m_\pi^2} + \ldots$$

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

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 $\not{CP}$

2) how essintial role of EW penguin contribution to $\not{CP}$ in $K^0 \to \pi\pi$ and $K^\pm \to 3\pi$ decays.

The large uncertainty of the pure theoretical predictions for ε'/ε, characterised by the results

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

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

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

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

Is it so for $\not{CP}$ in $K^\pm \to 3\pi$ 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 paremeters of the theory extracted from data on $K_L \to 2\pi$ decays.

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

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

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

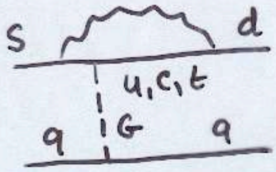
$$O_3 = \bar{s}_L \gamma_\mu d_L \cdot \bar{u}_L \gamma_\mu u_L + \bar{s}_L \gamma_\mu u_L \cdot \bar{u}_L \gamma_\mu d_L + 2\bar{s}_L \gamma_\mu d_L \cdot \bar{d}_L \gamma_\mu d_L - 3\bar{s}_L \gamma_\mu d_L \cdot \bar{s}_L \gamma_\mu s_L \quad (\{27\},\ \Delta I = \tfrac{1}{2})$$

$$O_4 = \bar{s}_L \gamma_\mu d_L \cdot \bar{u}_L \gamma_\mu u_L + \bar{s}_L \gamma_\mu u_L \cdot \bar{u}_L \gamma_\mu d_L - \bar{s}_L \gamma_\mu d_L \cdot \bar{d}_L \gamma_\mu d_L \quad (\{27\},\ \Delta I = \tfrac{3}{2})$$

$\Delta I = \frac{1}{2}$:

$$O_5 = \bar{s}_L \gamma_\mu \lambda^a d_L \Big(\sum_{q=u,d,s} \bar{q}_R \gamma_\mu \lambda^a q_R\Big)$$

$$O_6 = \bar{s}_L \gamma_\mu d_L \Big(\sum_{q=u,d,s} \bar{q}_R \gamma_\mu q_R\Big)$$



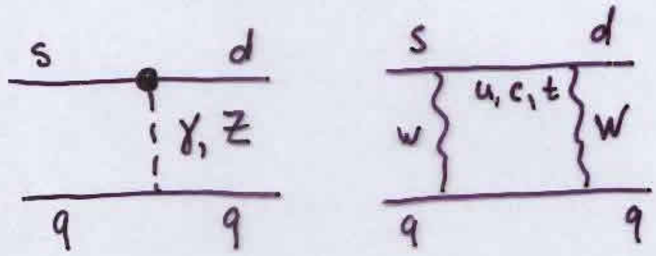
QCD "penguin"

$\Downarrow$

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:



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

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

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

Coefficients C_{5-8} have the imaginary parts necessary for $\cancel{CP}$.

Using the Fierz reordering transformations in spinor and color spaces

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

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

$$O_8 = 3\,O_7$$

Bosonization of these operators

Bardeen, Buras, Gerard '87

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

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

Nonlinear realization of chiral symmetry

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

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

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

For this reason

$$O_5 \sim$$

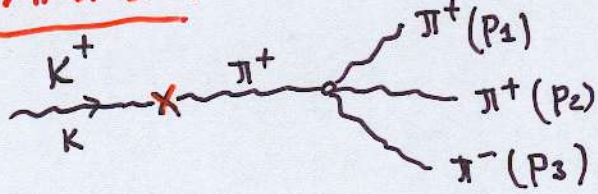
$$\sim\Big\{\underbrace{(U^+U)_{23}}_{=0} - \frac{1}{\Lambda^2}\underbrace{\left(U^+\cdot\partial^2 U + \partial^2 U^+\cdot U\right)_{23}}_{\sim p^2/\Lambda^2}\Big\}$$

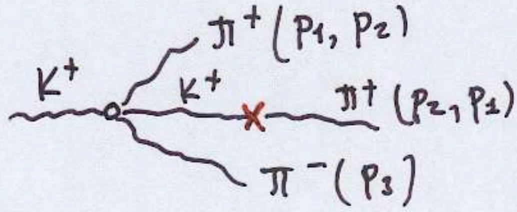
But

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

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

For $K^+\to\pi^+\pi^+\pi^-$:





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

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

Though $c_7 \sim \alpha_{em}\, c_5$, but the contribution of $C_7 O_7$ is enhanced by absence of $\Delta I = \frac{3}{2}$ suppression and by factor $\Lambda^2/m_K^2 \approx 4$!

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(d)

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

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

$$\gamma = \sqrt{2}\, G_F \sin\theta_c \cos\theta_c \cdot C_7$$

Feinberg, Kabir, Weinberg' 1959

$$\pi^- \to \pi^- + \beta K^- \quad , \quad K^+ \to K^+ - \beta \pi^+ \qquad \beta = \gamma^* \frac{F_\pi^2 r^2}{2(m_K^2 - m_\pi^2)}$$

$$\pi^+ \to \pi^+ + \beta^* K^+ \quad , \quad K^- \to K^- - \beta^* \pi$$

These transformations remove the non-diagonal terms from ΔL^{mass}.

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

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

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

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

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

Some information on the magnitudes of c_i can be extracted from $K \to 2\pi$ decays.

$$M(K_1^0 \to \pi^+\pi^-) = A_0 e^{i\delta_0} - A_2 e^{i\delta_2}$$

$$M(K_1^0 \to \pi^0\pi^0) = A_0 e^{i\delta_0} + 2A_2 e^{i\delta_2}$$

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

where

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

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

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

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

Contributions of $\tilde{c}_7 O_7$ into $\mathrm{Re}\,A_0$ and $\mathrm{Im}\,A_0$ are neglected.

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

$$C_4 = 0.328 \,; \quad c_1 - c_2 - c_3 + \frac{32}{9}\beta \, \mathrm{Re}\,\tilde{c}_5 = -10.13$$

At $c_1 - c_2 - c_3 = -2.89$ (SVZ, Okun)

$$\frac{32}{9}\beta \, \mathrm{Re}\,\tilde{c}_5 = -7.24$$

Using the general relation

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

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

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

where $\Omega_{\eta+\eta'}$ takes into account the effects of $K^0 \to \pi^0 \eta(\eta') \to \pi^0 \pi^0$ transitions.

Introducing the notations

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

and using

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

Ali, London 2001

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

$$\boxed{x\,(1 - y) = 0.40\,(1 \pm 0.22)}$$

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

$$y = \frac{\Pi_2}{\omega} \Big/ \Pi_0 (1 - \Omega_{\eta+\eta'})$$

According Bertolini et al'2001 $y \approx 0.3$ But $\frac{\varepsilon'}{\varepsilon} = 1.3 \left(\frac{\varepsilon'}{\varepsilon}\right)^{ex}$

and hence $\underline{x = 0.57 \pm 0.12}$.

Hambye et al' 2003 give $y \approx 0.5$

$\underline{x = 0.80 \pm 0.18}$

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

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 $K^\pm \to \pi^\pm \pi^\pm \pi^\mp$ decays will allow to determine the real value of EWP contribution.

3. Decay $K^{\pm} \to \pi^{\pm}\pi^{\pm}\pi^{\mp}$

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

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

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

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 technics (Vainshtein, Zakharov'70)

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

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

where

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

Taking into account the CP-odd contribution produced by $\mathrm{Im}\,\tilde{c}_{5,7}$ we obtain

$$M(K^{\pm} \to \pi^{\pm}\pi^{\pm}\pi^{\mp}(p_3)) = k\left[1 + i a_{KM} + \frac{1}{2} g\, Y\,(1 + i b_{KM}) \pm \ldots\right]$$

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

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

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

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

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

Important point

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

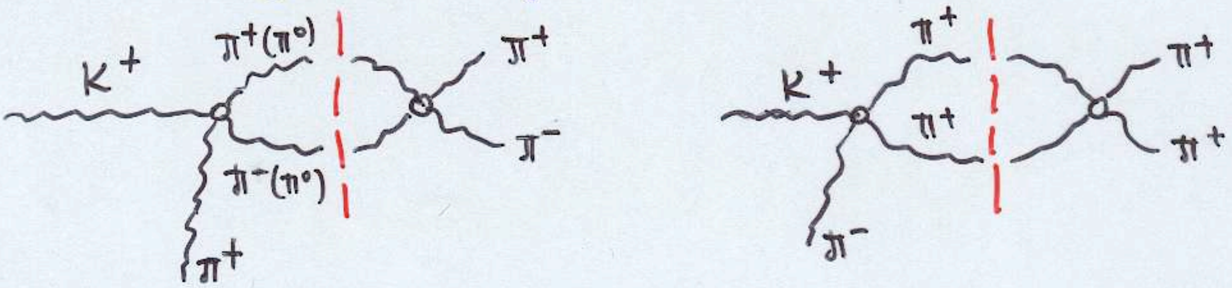
Then
$$M(K^{\pm} \to \pi^{\pm}\pi^{\pm}\pi^{\mp}(p_3)) = k\left[1 + \frac{1}{2} g\, Y\,(1 - i(b_{KM} - a_{KM})) \pm \ldots\right]$$

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.

Then

$$M(K^+ \to \pi^+\pi^+\pi^-) = k\left[1 + \underset{\substack{\uparrow \\ \text{CP-even}}}{ia} + \frac{1}{2} g Y \left(1 + \underset{\substack{\uparrow \\ \text{CP-even}}}{ib} - i\underbrace{(b_{KM} - a_{KM})}_{\substack{\uparrow \\ \text{CP-odd}}}\right) + \dots\right]$$

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



Using

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

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

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

we find

$$\boxed{a=0.12065\ ;\quad b=0.714}$$

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

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

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

$$\left|M\left(K^+\to\pi^+\pi^+\pi^-(p_3)\right)\right|^2\sim 1+\frac{g}{1+a^2}Y\left(1+ab+a(b_{KM}-a_{KM})\right)$$

$$\left|M\left(K^-\to\pi^-\pi^-\pi^+(p_3)\right)\right|^2\sim 1+\frac{g}{1+a^2}Y\left(1+ab-a(b_{KM}-a_{KM})\right)$$

$$\boxed{R_g=\frac{g^+-g^-}{g^++g^-}=+\frac{a(b_{KM}-a_{KM})}{1+ab}}$$

At the fixed above parameters and $\Omega_{\eta+\eta'} = 0.25$ we obtain

$$\left(R_g\right)_{p^2\text{-appr.}} = 0.030\,\frac{\mathrm{Im}\,\tilde{c}_5}{\mathrm{Re}\,\tilde{c}_5}\left(1-14.9\,\frac{\mathrm{Im}\,\tilde{c}_7}{\mathrm{Im}\,\tilde{c}_5}\right) =$$

$$= -(2.44 \pm 0.44)\,10^{-5}\,x\left(1-\frac{0.13\pm 0.03}{x}\right)$$

At $x \approx 1$ this result is larger than obtained by L. Maiani and N. Paver " The second DAΦNE 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 $(G^a_{\mu\nu})^2$ states can be calculated using the linear σ-model elaborated previosly (E. Sh'93 Nucl. Phys B 409, 87, 1993)

$a(\xi=-0.225;\ p^2+p^4) = 0.16265$	$a(\xi=0;\ p^2) = 0.1206$
$b(\xi=-0.225;\ p^2+p^4) = 0.762$	$b(\xi=0;\ p^2) = 0.714$

$$\left(R_g\right)_{(\xi=-0.225;\ p^2+p^4)} = 0.039\,\frac{\mathrm{Im}\,\tilde{c}_5}{\mathrm{Re}\,\tilde{c}_5}\left(1-11.95\,\frac{\mathrm{Im}\,\tilde{c}_7}{\mathrm{Im}\,\tilde{c}_5}\right) =$$

$$= -(3.0 \pm 0.5)\,10^{-5}\,x\left(1-\frac{0.11\pm 0.025}{x}\right)$$

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 δ_0^0.

According to definition

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

$a \approx \tan \delta_0^0(s_0)$, 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_{e4} decay

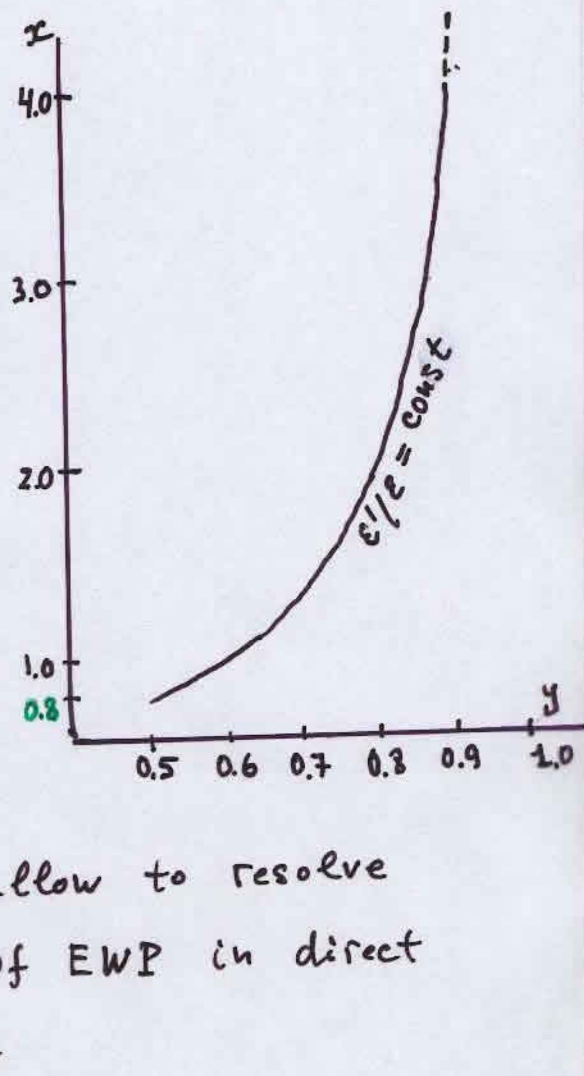
$\delta_0^0(s_0) = (7.50 \pm 2.85)^\circ \Rightarrow a = 0.13 \pm 0.05$ Rosselet at al'77

$\delta_0^0(s_0) = (8.4 \pm 1.0)^\circ \Rightarrow a = 0.148 \pm 0.018$ Pislak et al.'93

Conclusion

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 ε'/ε in view of relation
$\varepsilon'/\varepsilon \sim x(1-y) = 0.40(1 \pm 0.22)$
according to which ε'/ε could be the same for $x = 0.8$ and $x = 4.0$



3. Measurement of R_g in $K^\pm \to \pi^\pm \pi^\pm \pi^\mp$ 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 $R_g(x=4.0) \,/\, R_g(x=0.8) = 5.6$

hep-ph/0405229