

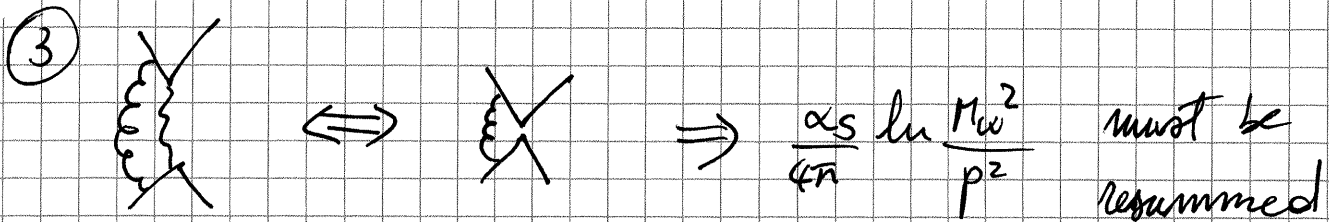
Recap:

① No tree-level FCNC in the SM, flavour change only via the exchange of W^\pm ;

② Tree-level W exchange admits an OPE at low energies:

$$\langle \text{tree} \rangle = \langle Q_1 \rangle + \langle D=8 \rangle \quad \Leftrightarrow \quad \frac{1}{k^2 - M_W^2} \approx \frac{-1}{M_W^2} \sum_{n=0}^{\infty} \frac{k^2}{M_W^2}$$

$$= \langle Q_1 \rangle + \mathcal{O}\left(\frac{p^2}{M_W^2}\right)$$

③ 

$$\Rightarrow \frac{\alpha_s}{4\pi} \ln \frac{M_W^2}{p^2} \quad \text{must be resummed}$$

Use RGE: match at $\mu \sim M_W$, run down to μ_H , evaluate matrix element. IR physics identical in full and effective theory, UV one encoded in \overline{MS} WC

practical recipe to resum $\alpha_s^{m+n} \left(\ln \frac{M_W^2}{p^2}\right)^m$:

a) match at $\mathcal{O}(\alpha_s^{m-1})$

b) run at $\mathcal{O}(\alpha_s^m)$

c) evaluate M.E. at $\mathcal{O}(\alpha_s^{m-1})$

Scale and scheme dependence cancel out at the desired order

④ also loop-mediated FCNC admit an OPE at low energies (for heavy quark contributions). GIM mechanism plays a role in determining the scaling in M_W : power GIM or log GIM.

$\Delta F=2$, $\Delta F=1$ penguins, radiative + semileptonic,

la regola $\Delta I = \frac{1}{2}$

$$A_{K^0 \rightarrow \pi^+ \pi^-} = A_0 e^{i\delta_0} + \frac{A_2}{\sqrt{2}} e^{i\delta_2}$$

$$A_{K^0 \rightarrow \pi^0 \pi^0} = A_0 e^{i\delta_0} - \frac{A_2}{\sqrt{2}} e^{i\delta_2}$$

$$K_{K^+ \rightarrow \pi^+ \pi^0} = \frac{3}{2} A_2 e^{i\delta_2}$$

Cosa sono δ_0 e δ_2 ?

~~$$S = \begin{pmatrix} 1 & T_0 & T_2 \\ T_0 & S_{00} & 0 \\ T_2 & 0 & S_{22} \end{pmatrix} = \begin{pmatrix} K \rightarrow K & K \rightarrow (\pi\pi)_0 & K \rightarrow (\pi\pi)_2 \\ (\pi\pi)_0 \rightarrow K & (\pi\pi)_0 \rightarrow (\pi\pi)_0 & 0 \\ (\pi\pi)_2 \rightarrow K & 0 & (\pi\pi)_2 \rightarrow (\pi\pi)_2 \end{pmatrix} = \begin{pmatrix} 1 & -iT_0 & 0 \\ -iT_0 & e^{i\delta_0} & 0 \\ -iT_2 & 0 & e^{i\delta_2} \end{pmatrix}$$~~

~~$$S^\dagger S = \mathbb{1} \Rightarrow \text{all'ordine 1 in } T$$~~

~~$$T_0 + S_{00} T_0^* = 0 \Rightarrow T_0 = -e^{i\delta_0} T_0^* \Rightarrow \text{Arg } T_0 = \pi$$~~

~~$$T_2 + S_{22} T_2^* = 0 \Rightarrow T_2 = -e^{i\delta_2} T_2^* \Rightarrow \text{CP GW.}$$~~

~~$$i(T_0)^* e^{i\delta_0} - iT_0 = 0 \Rightarrow T_0 = e^{i\delta_0} T_0^* \Rightarrow T_0 = |A_0| e^{i\delta_0}$$~~

$$|A_0| = 5.46 \cdot 10^{-7} \text{ M}_K$$

$$|A_2| = 0.25 \cdot 10^{-7} \text{ M}_K$$

$$\Rightarrow \left| \frac{A_2}{A_0} \right| \approx \frac{1}{22}$$

$$I_+ d = u \quad I_+ \bar{u} = -d \quad I_- u = d \quad I_- \bar{d} = -u$$

$I_+ O_- = 0 \Rightarrow O_-$ è la componente $+\frac{1}{2}$ di un doppietto

O_+ invece è $\frac{3}{2}$ e $\frac{1}{2}$.

$$S = \begin{pmatrix} K \rightarrow K & K \rightarrow (\pi)_0 & K \rightarrow (\pi)_2 \\ (\pi)_0 \rightarrow K & (\pi)_0 \rightarrow (\pi)_0 & 0 \\ (\pi)_2 \rightarrow & 0 & (\pi)_2 \rightarrow (\pi)_2 \end{pmatrix} = \begin{pmatrix} 1 & -iT_0 & -iT_2 \\ -iT(T_0) & e^{2i\delta_0} & 0 \\ -iT(T_2) & 0 & e^{2i\delta_2} \end{pmatrix}$$

$$S^\dagger = \begin{pmatrix} 1 & iT(T_0)^* & iT(T_2)^* \\ iT_0^* & e^{-2i\delta_0} & 0 \\ iT_2^* & 0 & e^{-2i\delta_2} \end{pmatrix}$$

$$S^\dagger S = \mathbb{1} \Rightarrow -iT_0 + e^{2i\delta_0} iT(T_0)^* = 0$$

$$T(T_0) = CP(T_0) \quad T_0 = A_0 e^{i\delta_0}$$

$$CP(T_0) = A_0^* e^{i\delta_0}$$

$$-iA_0 e^{i\delta_0} + e^{2i\delta_0} i(A_0^* e^{i\delta_0})^* = 0$$

$$A_0 e^{i\delta_0} = e^{2i\delta_0} A_0 e^{-i\delta_0} \Rightarrow \delta_0 = \bar{\delta}_0 \quad \text{Watson Theorem}$$