Minimal Flavour Violation for Leptons

Federica Palorini

Institut de Physique Nucléaire de Lyon

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Minimal flavour violation for quarks

- SM description of flavour violating processes is well confirmed by experiments

$$\mathscr{L}_{kinetic} = i(\bar{Q}^i \not{D} Q_i + \bar{u}_R^i \not{D} u_{Ri} + \bar{d}_R{}^i \not{D} d_{Ri})$$

$\Rightarrow$ Accidental flavour symmetry

$$\mathscr{L}_{yukawa} = \bar{Q}^{i\alpha} (Y_u)^j_i u_{Rj} \tilde{\phi}_\alpha + \bar{Q}^{i\alpha} (Y_d)^j_i d_{Rj} \phi_\alpha + \text{h.c.}$$

- $Y_u Y_u^\dagger$ and $Y_d Y_d^\dagger$ determine two bases in the Q space

$\Rightarrow$ *FV processes* and *CP violation* mediated by the CKM matrix

Minimal Flavour Violation

- Physics at TeV scale strongly constrained :

  $\Rightarrow$ Minimal Flavour Violation[1]

> The Yukawa couplings are the only source
> of quark flavour symmetry breaking

  $\Rightarrow$ Predictive framework that encompasses many models

[1] D'Ambrosio, Giudice, Isidori, Strumia, hep-ph/0207036

The lepton sector

Lepton sector differs sensibly :

- In the Standard Model :

$$\mathscr{L}_{kinetic} = i(\bar{L}^i \not{D} L_i + \bar{e}^i_R \not{D} e_{Ri})$$

$$\mathscr{L}_{yukawa} = \bar{L}^{i\alpha} (Y_e)^j_i e_{Rj} \phi_\alpha + \text{h.c.}$$

- New physics exists in this sector : neutrino oscillations have been observed ($\Rightarrow$ neutrino mixing driven by U_{MNS})
- Upper bounds on FV processes *(e.g.* $BR(\mu \to e\gamma) < 1.2 \times 10^{-11}$*)*
- Neutrinos are only weakling interacting $\Rightarrow$ Majorana masses are allowed

Majorana neutrinos

Majorana neutrinos $\Rightarrow$ Non-renormalisable light mass operator

$$(L_j H_u)\mathbf{K}^{jk}(L_k H_u)$$

$\Rightarrow$ Flavour violating processes are not necessarily controlled by the U_{MNS} mixing matrix

Two possible cases :

- *Enlarged symmetry group* (e.g. models with ν_R *seesaw model*) :
- *SM flavour symmetry group* (no new flavoured particles, e.g *neutrino masses from loops in RPV susy models*)

Possible definitions of MFVL

Different possible definitions of MFV for Leptons :

1. Y_e and m_ν are the basis choosing operators in the L space [2]

   $\Rightarrow$ Flavour Violation driven by the U_{MNS} matrix

   - Minimal scenario, so very predictive

2. MFV as a restriction on *renormalizable* couplings [3] :

New renormalizable interactions can choose only one more basis in the L space

   $\Rightarrow$ FV processes are not necessarily controlled by the U_{MNS} mixing matrix

   - Extensive definition which includes many models

[2] Cirigliano, Grinstein, Isidori, Wise, hep-ph/0507001
[3] Davidson, Palorini, hep-ph/0607329

Conclusions

- In the quark sector FV processes are observed to be controlled by the CKM mixing matrix

$\Rightarrow$ MFV is a useful prescription for the flavour structure of New Interactions

- In the lepton sector :
  - Different neutrino mass generating mechanisms are allowed
  - Upper bounds on FV processes in the lepton sector

$\Rightarrow$ Different possible definitions of MFVL

- We have explored the possibility of defining a MFV for Leptons on renormalizable couplings and which could include different models