March CLFV coffee hour

S. Davidson (U. Montpellier), B. Echenard (Caltech)

Welcome to our monthly CLFV coffee hour

While the Snowmass process is on pause, we wanted to stay in contact and keep exchanging on the physics we like.

We decided to organize a monthly coffee hour – to be held every last Thursday of the month until the summer – to host a free form environment to discuss broad CLFV physics, related or not to Snowmass.

We will try to propose a conversation topic every meeting, but you should feel free to steer the discussion in any direction you like or ask (difficult) questions. Feel free to send suggestions for the next coffee hours.

This event won't be recorded, but we will try to post a brief summary on the indico page.

Today's topic: relations among CLFV and neutrino physics

Enjoy your coffee (or glass of wine for our European friends)

From neutrino masses to LFV

1. LFV is New Physics that exists: $[m_\nu]_{ij} \Rightarrow$ **LFV**

   we all know that non-zero neutrino masses and mixing angles, imply that charged leptons change flavour in contact interactions...
   ...because thats what happens in the quark sector: GIM-suppressed FCNC arise via loops.

   Sadly, if put neutrino masses and mixing angles in the quark formulae, then GIM suppression implies

$$BR(LFV) \propto \left(\frac{m_\nu^2}{m_W^2}\right)^2 \sim 10^{-48}$$

2. Do neutrino masses say other things about LFV ?

   (not that I remember just now)

A route between neutrino masses and LFV: models

1. neutrino masses require new particles or interactions $(New\ Physics\ (:\ )$, beyond the SM-defined-without-ν_R.

2. BSM models usually have many parameters; fix some to reproduce observed ν mass matrix, vary others and plot LFV rates ...

   $\Rightarrow$ welcome $Complementarity$ of LFV and ν-masses

   in determining model parameters

... but can one relate LFV to $[m_\nu]$ without a model?

$\star$ for instance: if see LFV, are neutrinos massive?

Sadly; seems no: if have LFV without LNV, then neutrinos cannot have Majorana masses. And only can have Dirac masses if there is are ν_R...

$\star$ if observe, or not observe, LFV, can one conclude anything relevant to neutrino expts? (Surely yes? Because the W vertex connects a charged lepton to a neutrino—so diagrammatically, anything one can do, the other can do too?)

What does LFV say about neutrino masses?

1. neutrino experiments look for "Generalised/Non-Standard" contact interactions, of neutrinos with matter, eg

$$2\sqrt{2}G_F\varepsilon_{ij}(\overline{\nu}_i\Gamma\nu_j)(\bar{f}\Gamma f) \quad , \quad f \in \{u, d, e\}$$

hep-ph/0302093
0907.0097
1909.07406

If such interactions were mediated by "heavy" New Physics, can use EFT to relate to LFV contact interactions: *eg* consider $i, j = e, \mu$. That vertex possibly accompagnied by $(\overline{e}\Gamma\mu)(\bar{f}\Gamma f)$. Or can decorate with Ws, Higgses and obtain the LFV interaction.

2. Can LFV expts say things about other hypothetical neutrino properties?
eg sticky neutrinos for addressing H0 tension in cosmology? add sterile ν_s, with self-interactions via "light" boson (? MeV-GeV?) and $\sim$ seesaw-induced mass mixing to activeνs...

Or other light particles from DM scenarios? if they have LFV interactions, can one see them?
How to look for crazy things like $\mu \to eZ'$ or $\mu \to e\phi$?($= \mu \to e +$ invisible)
...

Why no "C" preceding LFV on my slides

1. flavour is $only$ defined for charged leptons!
   (three flavours $\in \{e, \mu, \tau\}$, no "flavour" assigned to neutrino mass eigenstates.)

2. so the only flavour that ever changes in the lepton sector is charged lepton flavour
   ... also in neutrino oscillations, one measures charged lepton flavour change:

   μ decays (at JPARC) $\longrightarrow$ $\longrightarrow$ $\longrightarrow$ $\longrightarrow$ e appears in SuperK

3. LFV differs from neutrino oscillations by occuring $at\ a\ point$; its a contact interaction.

The letter in "LFV" I want to change is the last one: Violation is a violent word (suitable for breaking symmetries that are almost sacro-saint: CPT, CP?).
Quark people use "Change": FCNC...

...we could do LFC ...