Constraining two Higgs doublet models with heavy lepton decays

Zofia Olszewska

Institute of Theoretical Physics, University of Warsaw

EPIPHANY 2023

Based on the work by
Z.Olszewska, S.Pokorski, K.Sakurai arXiv: hep-ph 23XX.

Outline

1. Motivation
2. Mechanisms of LFUV
3. Calculation of tau decay
4. Results
5. Conclusions and Outlook

Motivation

- Focus on indirect searches for NP effects in precision observables.
- Search for the violation of (approximate) symmetries of the SM.
- We can observe sizable effects even if the mass scale is quite high.

Lepton Flavor Universality

- Lepton Flavor Universality is as a symmetry of the SM at the Lagrangian level
- The aim of this work is to make constraints on SUSY parameters by considering lepton flavour universality in τ decays.
- Sensitivity to beyond SM processes because of the high τ mass $\rightarrow$ enhanced couplings to a hypothetical charged Higgs boson or other non-SM processes.

$$\mathcal{R}_D = \frac{\Gamma(B \rightarrow D\tau\bar{\nu})}{\Gamma(B \rightarrow D\{e/\mu\}\bar{\nu})} \tag{1}$$

and

$$\mathcal{R}_{D^*} = \frac{\Gamma(B \rightarrow D^*\tau\bar{\nu})}{\Gamma(B \rightarrow D^*\{e/\mu\}\bar{\nu})} \tag{2}$$

Experimental measurements

Particle Data Group Average (2016)

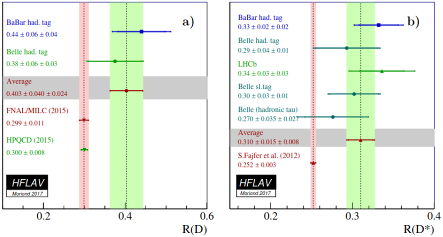


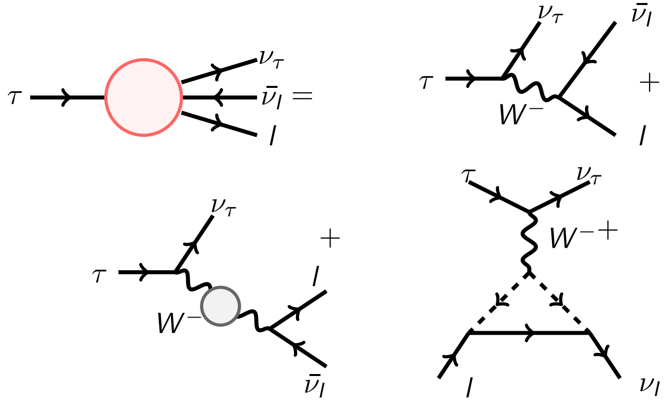
Figure 67: (a) Measurement of $\mathcal{R}(D)$ and (b) $\mathcal{R}(D^*)$. The average is the projection of the average obtained from the combined fit.

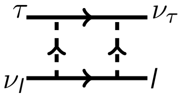
Parameter	σ
$R(D)$	2.2
$R(D^*)$	3.4
combined	3.9

Table: SM deviation

One loop corrections to tau decay

Tree-level process present in the SM.





Same diagrams with charged Higgs $H^{\pm}$.

Results

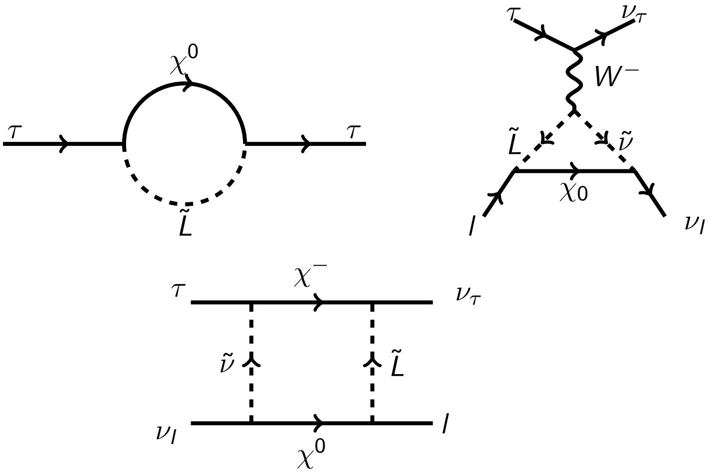
In the framework of the MSSM the non-universal contributions arise from

- tree level $H^{\pm}$
- different slepton masses in the loops.

First type suppressed by

$$\frac{m_\tau m_l}{M^2_{H^\pm}} \tan^2\beta \tag{3}$$

Dominant contributions



Conclusions and Outlook

1. Perform the complete 1-loop calculation of $\tau \to \mu/e\nu_\tau\nu_l$
2. Update the limits for sparticles based on the experimental data.
3. Include other τ decays (f.e. $\tau \to \pi^-\nu_\tau$).

BACKUP

SM predictions

Compared to $B^+ \to \tau\nu_\tau$, the $B \to D^{(*)}\tau\nu_\tau$ decay has advantages:

- the branching fraction is relatively high, because it is not Cabibbo-suppressed,
- it is a three-body decay allowing access to many observables besides the branching fraction, such as $D^{(*)}$ momentum, q^2 distributions, and measurements of the D^* and τ polarisations

The SM predictions:

- $R(D) = 0.300 \pm 0.008$
- $R(D) = 0.252 \pm 0.003$