Lepton Flavour Violating $\tau$ decays in a 2HDM with SU(3) Yukawa matrices

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Abstract. Using the Lepton Flavor Violating (LFV) decay of $\tau$ with production of a pseudo-scalar neutral meson $P^0$, we calculate the parameters space of a version of 2HDM where the Yukawa matrix generated through a unitary transformation of the diagonal mass matrix. This unitary transformation corresponds to a particular invariant subgroup of SU(3). We study the channel $\tau \rightarrow eK^0_s$ and demonstrate that it is possible to have non small couplings at the same time a LFV decay rate very small. This analysis shed light on the flavor structure in the frame of such group. This model is a particular case of the Partially Aligned 2HDM and motivates the analysis of more channels using this model for Yukawas.

1. Introduction

After the discovery of a scalar particle with all features of the Higgs boson, the Standard Model (SM) is the best description of particles at electroweak scale, nevertheless this discovery also leaves many open questions. Most of the lack of answers to these questions is related with the so called Flavor Problem where one important task is to understand the relations between the masses of fermions and the mixing angles. Likewise, many extensions of the SM have been proposed in order to parametrize possible new physics effects, although this has the disadvantage of introducing additional free parameters that have to be determined by experiments.

The 2HDM is an economical extension of SM that has been amply studied because it has many new phenomenology and could represent low energy limit of more general theories, for instance the low energy versions of SUSY models. Different versions of the 2HDM with NFC [1, 2], that introduce a $Z_2$ symmetry in the scalar sector to prevent Flavour Changing Neutral Currents (FCNC), have captured the attention due to its small number of free parameters. Also there are popular versions that are similar to low energy limits of models with extras symmetries, for instance the MSSM model [3]. The 2HDM with CP conserving VEV’s contains two additional charged scalars, two neutral scalars and one neutral pseudo-scalar resulting in a rich phenomenology extending the SM. A review of this model is [4], and references therein.

The main drawback in versions that do not contain NFC, for instance the version III [5, 6], is the big number of free parameters. Usually, to reduce these parameters and to control the FCNC, some textures have been used for the Yukawa matrix shedding interesting results [7, 8, 9]. Also some efforts to reduce the free parameters have been done using experimental measurements of mixing angles. An example in the quark sector is given in [10].
From the phenomenological point of view, experiments with fermions determine directly or indirectly mixing matrices, namely for quarks the CKM matrix and for the leptons the PMNS matrix. Likewise in the mass basis, the diagonal mass matrix is determined through resonances. Although it is known that there exists a relation between masses and mixings, at this level these parameters can be considered as inputs of an extended model. There exist many approaches that build mass matrices. One of the most important ones is the 4-zero texture that has been proved in several contexts. One remarkable feature of this texture is that only 4 parameters are enough to describe both, quarks sector and the leptonic sector [11].

Although a general version of 2HDM has a rich phenomenology, experimental determination of free parameters is very difficult and highly dependent of the model. On the other hand a physical interpretation of this parameters is needed in terms of an underlying yet unknown complete flavor theory. In this sense, here we propose a model to rewrite the Yukawa matrices as the result of a unitary-like transformation generated by Gell-Mann matrices in a particular representation of the flavor basis as a form to inquire a flavor structure. In order to reduce the free parameters of the model we assume that only an invariant subgroup of SU(3) relates up-type quarks with down-type quarks. As a result of this parametrization there is one less parameter than in other successful approaches as the 4-zero textures.

As an application and to demonstrate that this model is phenomenologically viable, we calculate the lepton flavor violating couplings of semi-leptonic $\tau$ decays into one pseudo-scalar meson and a lepton. This decays with LFV are considered in a version of the 2HDM where the main contribution to the new physics comes from a pseudo-scalar interaction, that is, the interchange of the pseudo-scalar $A^0$. For the channel $\tau \rightarrow e K^0_s$ it is shown that the unitary property of CKM matrix suppresses naturally this processes, as seen in the experimental measurements even for non small couplings with scalar $A^0$.

2. Yukawa matrices generated by SU(3)

To generate a texture matrix using the fermion masses as inputs we make a flavor transformation of the form

$$T^{f'} = \xi A^f_L D^f A^f_R$$

where $D_f \equiv \text{diag}(m_f^1, m_f^2, m_f^3)$ is the diagonal matrix, containing the fermion masses in normal order, for the $f = u, d, \ell, \nu$ flavors. On the other hand $\xi$ is in general a complex number and $A_L, A_R$ are $3 \times 3$ complex matrices. Also we have that in general $f' \neq f$. This transformation is general enough to construct any phenomenological texture because it has a big number of free parameters. This type of transformations are the starting point to introduce several hypothesis about the flavor structure for texture matrices. Transformations of the form (1) can be written such as the FCNC as in the Partially Aligned 2HDM (PA-2HDM) [12]. In this work we make the following assumptions:

- The matrices $A^f_L$ and $A^f_R$ are $SU(3)$ matrices that belong to a particular invariant subgroup, i.e. U-Spin, V-Spin and S-Spin.
- In order to reduce the number of free parameters we impose $A^f_L = A^f_R$, which means that the fermions transformation is unitary.
- For simplicity the scale parameter is set by $\xi = 1$ and $f'$ is the up-type flavor ($u$) and $f$ is the down-type flavor ($d, \ell$).

We rewrite the decay rates in terms of the parameters of a unitary transformation in order to explore whether the phenomenology of $\tau$ decays can say something about the flavor structure in the frame of the SU(3) group. The second assumption says that the matrix that diagonalizes the mass matrix has any of the forms showed in the Table 2. The observables with less experimental error are the masses and mixings of fermions, thus we take these values as inputs.
Subgroup | Generators
---|---
S-Spin (SU(2)) | $\lambda_1, \lambda_2, \lambda_3$
U-Spin | $\lambda_4, \lambda_5, \frac{1}{7}(\sqrt{3}\lambda_3 + \lambda_8)$
V-Spin | $\lambda_6, \lambda_7, \frac{1}{7}(\sqrt{3}\lambda_3 - \lambda_8)$

Table 1. Generators of the invariant subgroups of SU(3).

Table 2. General form of matrix representation of invariant subgroups of SU(3), $a_0$, $B$'s are real and $A$'s are complex parameters.

As we can see, the matrices have 4 real free parameters. In terms of textures definitions, these matrices corresponds to 2-zero texture matrices and can be used to diagonalize mass matrices.

3. SU(3) Yukawa interactions in the 2HDM

In the context of a 2HDM, the Yukawa matrices in the mass basis takes the form

$$D^f = \frac{1}{\sqrt{2}} \left( v_1 \hat{Y}^f_1 + v_2 \hat{Y}^f_2 \right)$$

where $v_1 = v \cos \beta$ and $v_2 = v \sin \beta$. Once a Yukawa matrix is determined in the mass basis, the second one can be calculated. As an hypothesis we assume that Yukawa matrices have the form of (1), so we can write

$$\hat{Y}^d_{X'2} = (\sqrt{2}G_F)\frac{i}{2} U^d_{X'X} D^d U^d_{X'X}$$

$$\hat{Y}^u_{X'2} = (\sqrt{2}G_F)\frac{i}{2} U^d_{X'X} V_{CKM}^\dagger D^u V_{CKM} U^d_{X'X}$$

and for the leptonic sector

$$\hat{Y}^\ell_{X'2} = (\sqrt{2}G_F)\frac{i}{2} U^\ell_{X'X} D^\ell U^\ell_{X'X}$$
In the mass basis the neutral interactions for the charged leptons can be cast as
\[ \text{given by} \]

because the phenomenology of meson decays has a scale of energy where the mass of neutrinos can be approximated to zero.

The Yukawa Lagrangian for charged leptons and quarks in the flavor basis for the 2HDM is
\[ \mathcal{L}_{\text{Y},X} = (\sqrt{2} G_F)^{1/2} \bar{d}_i \left( \begin{array}{c} m_i \cos \alpha \beta \delta_{ij} + \frac{\sin(\alpha - \beta)}{\sqrt{2} \cos \beta} (\tilde{Y}_{\text{X}X}^d)_{ij} \end{array} \right) H^0 + \left( -m_i \sin \alpha \cos \beta \delta_{ij} + \frac{\cos(\alpha - \beta)}{\sqrt{2} \cos \beta} (\tilde{Y}_{\text{X}X}^\ell)_{ij} \right) h^0 + \left( -m_i \tan \beta \delta_{ij} + \frac{1}{\sqrt{2} \cos \beta} (\tilde{Y}_{\text{X},X}^\ell)_{ij} \right) \gamma^5 A^0 \]

In the mass basis the neutral interactions for the charged leptons can be cast as
\[ \mathcal{L}_{\text{NC}}^{\text{2HDM}} = \sum_{ij} \sum_{a=1}^2 \left[ Q_{Li} \left( Y_{aij}^u \Phi_a u_{Rj} + Y_{aij}^d \Phi_a d_{Rj} \right) + Y_{aij}^\ell \bar{L}_{Li} \Phi_a \ell_{Rj} + \text{H.c.} \right] \]

where \( U_{XL}^f \) has one of the forms of the Table 2. As we can see, all scalar interactions are given by 4 parameters for every type of fermion, i.e. \( a_f, B_f, |A_f^X| \) and \( \phi_{A_f}^X \) with \( X, X' = S, U \) or \( V \) and \( f = u, d, \ell \). Here \( \phi_{A_f}^X \) is the phase of \( A_f^X \). In principle only 8 parameters are needed to describe all semileptonic decays of mesons. We do not deal with Yukawa matrix for the neutrino sector because the phenomenology of meson decays has a scale of energy where the mass of neutrinos can be approximated to zero.

The Yukawa Lagrangian for charged leptons and quarks in the flavor basis for the 2HDM is given by
\[ \mathcal{L}_{\text{2HDM}} = \sum_{ij} \sum_{a=1}^2 \left[ Q_{Li} \left( Y_{aij}^u \Phi_a u_{Rj} + Y_{aij}^d \Phi_a d_{Rj} \right) + Y_{aij}^\ell \bar{L}_{Li} \Phi_a \ell_{Rj} + \text{H.c.} \right] \]

In the mass basis the neutral interactions for the charged leptons can be cast as
\[ \mathcal{L}_{\text{NC}}^{2 \text{HDM}} = \sum_{ij} \sum_{a=1}^2 \left[ Q_{Li} \left( Y_{aij}^u \Phi_a u_{Rj} + Y_{aij}^d \Phi_a d_{Rj} \right) + Y_{aij}^\ell \bar{L}_{Li} \Phi_a \ell_{Rj} + \text{H.c.} \right] \]

where we have defined \( \tilde{Y}_{\text{X}X}^\ell = \frac{\tilde{Y}_{\text{X}X}^\ell}{(\sqrt{2} G_F)^{1/2}} \) in order to scale the parameters of the group to the electroweak scale. In this sense \( \tilde{Y}_{\text{X}X}^\ell = U_{XL}^\ell D_f U_{XL}^f \) and has units of mass.
4. Low energy flavor violation in $\tau$ decay with production of a pseudoscalar mesons

In order to make our phenomenological analysis we will work in the formalism of effective Lagrangian. In this case the LFV $\tau$ decay with production of neutral pseudo-scalar meson $\tau \rightarrow P^0 \ell$ can be calculated from the expressions (8),(9) and (10). The advantage of channels with only one pseudo-scalar meson in the final state and with CP conservation at couplings, is that only the scalar $A^0$ contributes to decay reducing drastically the number of free parameters involved. In the low energy regime the effective Lagrangian is given by

$$-\mathcal{L}_{\text{eff}}^{XX'} = \sqrt{2} G_F \frac{M_W^2}{M_{A^0}^2} g_{A^0 \ell_i \ell_j} X \left( \bar{\ell}_i \gamma^5 \ell_j \right) \sum_{q_i, q_m} g_{A^0 q_i q_m} \bar{q}_i \gamma^5 q_m$$

where the effective dimensionless couplings are given by

$$g_{A^0 \ell_i \ell_j} = \frac{1}{M_W} \left[ -m_i \tan \beta \delta_{ij} + \frac{1}{\sqrt{2} \cos \beta} \left( U_{XL}^d \ell_i \ell_j \right) \right]$$

(12)

$$g_{A^0 d_i d_j} = \frac{1}{M_W} \left[ -m_d \tan \beta \delta_{ij} + \frac{1}{\sqrt{2} \cos \beta} \left( U_{XL}^d \ell_i \ell_j \right) \right]$$

(13)

$$g_{A^0 u_i u_j} = \frac{1}{M_W} \left[ -m_i \cot \beta \delta_{ij} + \frac{1}{\sqrt{2} \sin \beta} \left( U_{XL}^d \ell_i \ell_j \right) \right].$$

(14)

Table 3. Updated experimental upper bounds of $\tau$ decays with LFV. In the third column we show the upper bounds on the couplings scaled with the mass of the pseudo-scalar $A^0$.

| Process       | Upper limit on BR [13] | $|g_{A^0 \ell_i \ell_j}| \frac{M_{A^0}}{m^2}$ | $\langle P | \sum_{q_i, q_m} (g_{A^0 q_i q_m} \bar{q}_i \gamma^5 q_m |0 \rangle$ |
|---------------|------------------------|---------------------------------------------|--------------------------------------------------------------------------------|
| $\tau \rightarrow e^+ \pi^0$ | $< 8.0 \times 10^{-8}$ | $< 2.13 \times 10^{-8}$ |
| $\tau \rightarrow \mu^+ \pi^0$ | $< 1.1 \times 10^{-7}$ | $< 2.67 \times 10^{-8}$ |
| $\tau \rightarrow e^- K^0_s$ | $< 2.6 \times 10^{-8}$ | $< 1.31 \times 10^{-8}$ |
| $\tau \rightarrow \mu^- K^0_s$ | $< 2.3 \times 10^{-8}$ | $< 1.32 \times 10^{-8}$ |
| $\tau \rightarrow e^- \eta$ | $< 9.2 \times 10^{-8}$ | $< 2.52 \times 10^{-8}$ |
| $\tau \rightarrow \mu^- \eta$ | $< 6.5 \times 10^{-8}$ | $< 2.27 \times 10^{-8}$ |
| $\tau \rightarrow e^- \eta'$ | $< 1.6 \times 10^{-7}$ | $< 4.24 \times 10^{-8}$ |
| $\tau \rightarrow \mu^- \eta'$ | $< 1.3 \times 10^{-8}$ | $< 1.32 \times 10^{-8}$ |

The decay width of $\tau$ with a neutral pseudo-scalar meson using the effective Hamiltonian (11) is [14],

$$\Gamma_{XX'}(\tau \rightarrow \ell P^0) = \frac{G_F^2}{8\pi} \left( \frac{M_W}{M_A^0} \right)^4 \left[ \left( m_\tau - m_\ell \right)^2 - m_P^2 \right] \frac{\lambda^{1/2}(m_\tau^2, m_\ell^2, m_P^2)}{m_\tau^2} \times |g_{A^0 \ell_i \ell_j}|^2 \langle P | \sum_{q_i, q_m} (g_{A^0 q_i q_m} \bar{q}_i \gamma^5 q_m |0 \rangle^2. \quad (15)$$

Using the experimental upper limit on the branching ratios we can calculate the parameters space for particular cases as the channel $\tau \rightarrow eK^0_s$.

Writing the couplings in terms of the parameters of the invariant transformation of $SU(3)$ we get several cases.
4.1. Couplings with the S-Spin subgroup

Using S-Spin transformation to generate the Yukawa matrix elements, we can calculate the couplings of the pseudo-scalar $A^0$ with fermions. In this work we consider only the processes at tree level with LFV in tau decay that produce a pseudo-scalar meson (see Table 3), thus in the lepton sector only the couplings $g^S_{A^0 \tau e}$, $g^S_{A^0 e\tau}$ are needed. From the expression (6), it is easy to see that LFV in these processes are identically zero leading to a plausible scenario of null LFV.

For completeness we write the couplings of $A^0$ to quarks that are implied in the LFV tau decays.

$$g^S_{A^0 uu} = \frac{m_t}{\sqrt{2}M_W \sin \beta} \left\{ \left( a^d_{S0} \right)^2 V^2_{ub} + \left[ V_{ud}(a^d_{S0} + B^d_S) + V_{us} \right] \left( V_{ud}(a^d_{S0} + B^d_S) + V_{us}A^s_S \right) \right\} \left( \frac{m_u}{m_t} \right)$$

$$+ \left( V_{us}(a^d_{S0} - B^d_S) + V_{ud}A^d_S \right)^2 \left( \frac{m_c}{m_t} \right) \right\}$$

$$g^S_{A^0 dd} = \frac{m_s}{\sqrt{2}M_W \cos \beta} \left[ \left| A^d_S \right|^2 + \left( a^d_{S0} + B^d_S \right)^2 - \sqrt{2} \sin \beta \right] \left( \frac{m_d}{m_s} \right) \right\}$$

$$g^S_{A^0 ss} = \frac{m_s}{\sqrt{2}M_W \cos \beta} \left[ \left( a^d_{S0} - B^d_S \right)^2 - \sqrt{2} \sin \beta + \left| A^d_S \right|^2 \right] \left( \frac{m_d}{m_s} \right) \right\}.$$

For the couplings with flavor violation we have

$$g^S_{A^0 uc} = \frac{m_t}{\sqrt{2}M_W \sin \beta} \left\{ \left( a^d_{S0} \right)^2 V_{ub}V_{sb} + \left[ V_{us}(a^d_{S0} - B^d_S) + V_{ud}A^d_S \right] \left( \frac{m_c}{m_t} \right) \right\}$$

$$+ \left( V_{ub}(a^d_{S0} + B^d_S) + V_{us}A^d_S \right) \left( V_{cd}(a^d_{S0} + B^d_S) + V_{cs}A^d_S \right) \left( \frac{m_u}{m_t} \right) \right\}$$

$$g^S_{A^0 ud} = \frac{m_s}{\sqrt{2}M_W \cos \beta} \left[ A^d_S(a^d_{S0} - B^d_S) + (a^d_{S0} + B^d_S)A^d_S \right] \left( \frac{m_d}{m_s} \right) \right\}.$$

4.2. U-Spin couplings

In this subgroup we have that $g^S_{A^0 e\mu} = 0$ thus for the decay that we are considering, the LFV appears only in the decays with electron with the coupling

$$g^S_{A^0 \tau e} = \frac{m_e}{\sqrt{2}M_W \cos \beta} \left[ A^d_S(a^d_{U0} - B^d_U) + (a^d_{S0} + B^d_S)A^d_S \right] \left( \frac{m_e}{m_t} \right) \right\}.$$

On the other hand, for the quark sector the couplings are

$$g^U_{A^0 uu} = \frac{m_t}{\sqrt{2}M_W \sin \beta} \left\{ V_{ub}(a^d_{U0} - B^d_U) + A^d_U V_{ub} \right\}^2 + \left( a^d_{U0} \right)^2 V^2_{us} \left( \frac{m_c}{m_t} \right)$$

$$+ \left( V_{ud}(a^d_{U0} + B^d_U) + A^d_U V_{ub} \right) \left[ V_{ud}(a^d_{U0} + B^d_U) + V_{ub}A^d_U \right] - \sqrt{2} \cos \beta \left( \frac{m_u}{m_t} \right) \right\}$$

$$g^U_{A^0 dd} = \frac{m_b}{\sqrt{2}M_W \cos \beta} \left[ A^d_U + \left( a^d_{U0} - B^d_U \right)^2 - \sqrt{2} \sin \beta \right] \left( \frac{m_d}{m_b} \right) \right\}$$

$$g^U_{A^0 ss} = \frac{m_s}{\sqrt{2}M_W \cos \beta} \left[ a^d_{U0} - B^d_U \right]^2 \left( \frac{m_s}{m_b} \right) \right\}.$$

$$g^U_{A^0 uc} = \frac{m_t}{\sqrt{2}M_W \sin \beta} \left\{ V_{ub}(a^d_{U0} - B^d_U) + A^d_U V_{ub} \right\} \left[ V_{ub}(a^d_{U0} - B^d_U) + A^d_U V_{ub} \right] \left( \frac{m_u}{m_t} \right)$$

$$+ \left[ V_{ud}(a^d_{U0} + B^d_U) + A^d_U V_{ub} \right] \left[ V_{ud}(a^d_{U0} + B^d_U) + V_{ub}A^d_U \right] \left( \frac{m_u}{m_t} \right) + \left( a^d_{U0} \right)^2 V_{ub}V_{cs} \left( \frac{m_c}{m_t} \right) \right\}$$

$$g^U_{A^0 sd} = \frac{m_s}{\sqrt{2}M_W \cos \beta} \left[ a^d_{U0} \right]^2 \right\}.$$
4.3. V-Spin couplings
In this case $g_{\nu e}^{V} = 0$ the LFV for decay with muons is given by

$$g_{\nu e}^{V} \frac{m_{\tau}}{\sqrt{2}M_{W} \cos \beta} \left[ \frac{A_{\nu}^{d}}{A_{\nu}^{u}} (a_{\nu}^{d} - B_{\nu}^{d}) + (a_{\nu}^{d} + B_{\nu}^{d}) \frac{m_{u}}{m_{\tau}} \right]$$

(28)

The couplings with quark sector is

$$g_{A_{u}us}^{V} = \frac{m_{u}}{\sqrt{2}M_{W} \sin \beta} \left( (a_{\nu}^{d}) - \sqrt{2} \cos \beta \right)$$

(29)

$$g_{A_{d}dd}^{V} = \frac{m_{d}}{\sqrt{2}M_{W} \cos \beta} \left\{ [V_{ub}(a_{0} - B) + V_{us}A] \right\}$$

$$+ [V_{us}(a_{0} + B) + AV_{ub}] [V_{ub}(a_{0} + B) + V_{us}A^{*}] \left( \frac{m_{u}}{m_{\tau}} \right)$$

$$+ ((a_{0})^{2}V_{ud}^{2} - \sqrt{2} \sin \beta) \left( \frac{m_{d}}{m_{\tau}} \right)$$

(30)

$$g_{A_{s}sa}^{V} = \frac{m_{s}}{\sqrt{2}M_{W} \cos \beta} \left[ A^{2} + ((a_{0} + B)^{2} - \sqrt{2} \sin \beta) \left( \frac{m_{s}}{m_{\tau}} \right) \right]$$

(31)

$$g_{A_{u}uc}^{V} = \frac{m_{t}}{\sqrt{2}M_{W} \sin \beta} \left\{ [V_{ub}(a_{0} - B) + V_{us}A] \right\}$$

$$+ [V_{us}(a_{0} + B) + AV_{ub}] [V_{cs}(a_{0} + B) + V_{ch}A^{*}] \left( \frac{m_{t}}{m_{\tau}} \right) + (a_{0})^{2}V_{ud}V_{cd} \left( \frac{m_{u}}{m_{\tau}} \right)$$

(32)

$$g_{A_{s}sd}^{V} = 0.$$  

(33)

As we can seen, using the S-Spin invariant subgroup there are no flavor violating $\nu$ decays. On the other hand U-Spin and V-Spin exclude flavor violating decays with $\mu$ and $e$ respectively. Although the couplings $g_{X_{f_{1}f_{2}}}^{U}$ are quite complicated even with this simple approximation there is a decay particularly interesting because depend on only 2 parameters, namely $\tau \rightarrow eK_{s}^{0}$ for the U-Spin case. Here the condition $m_{e} < < m_{\tau}$ leads to $g_{A_{f_{1}f_{2}}}^{U} \simeq \frac{m_{e}^{2}}{\sqrt{2}M_{W} \cos \beta}$, with $\zeta^{U}_{f_{1}f_{2}} = A_{f_{1}f_{2}}^{U}(a_{0}^{U} - B_{0}^{U})$. On the other hand $g_{X_{f_{1}f_{2}}}^{U}$ depends only on one parameter.

$$\Gamma(\tau \rightarrow eK_{s}^{0}) \simeq (8.606 \times 10^{-15} \text{GeV}^{5}) \times \frac{|\zeta^{U}_{f_{1}f_{2}}| \gamma_{a_{0}^{U} - B_{0}^{U}}^{4}}{M_{A}^{2}}(1 + \tan^{2} \beta)^{2}.$$  

(34)

Now using the upper bound of Table 3 we get the parameter space shown in the Figure 1.

5. Conclusions
In this work we have calculated the LFV couplings in the particular case where the flavor transformations correspond to a simple invariant subgroup $SU(3)$ transformation in a 2HDM with CP conservation at the tree level scalar interactions. We demonstrate that with this form the couplings are naturally suppressed controlling the FCNC and LFV processes. In particular we observed that the U-Spin flavor transformation leads to a small decay rate for $\tau \rightarrow eK_{s}^{0}$ although the couplings $g_{X_{f_{1}f_{2}}}^{U}$ are not small. An important case is the decays with $\tau \rightarrow e\eta$ and $\tau \rightarrow e\eta'$ that allows to find information of the parameter $a_{0}^{U}$, in terms of $\tan \beta, B_{0}^{U}$, and $A_{0}^{U}$, but with similar behavior for $|\zeta^{U}_{f_{1}f_{2}}|$. Nevertheless in order to reduce the space of parameters a global analysis is needed that includes the use of decays $\tau \rightarrow \ell P_{1}P_{2}$ with $P_{1}$ and $P_{2}$ pseudo-scalars mesons. In these processes we get at tree level the contributions of $H^{0}$ and $h^{0}$ that introduce the mixing angle for scalars.
α as the new parameter. This forces us to use more than τ decays to bound properly the space of parameters and might reduce drastically the range of values that could take |ζℓ|.

In this work we have shown how the introduction of suitable matrices coming from invariant subspaces of SU(3) can suppress the LFV processes, in particular S-Spin eliminate at all this kind of decays obtaining the same result at tree level as the SM. In the case of U-Spin and V-Spin there are LFV τ decays but only with electron and μ respectively, suppressed by the hierarchy of masses and CKM matrix elements. Thus Yukawa matrices coming from this kind of flavour transformations are viable in a phenomenological sense.

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