Flavour-changing neutral current transitions (FCNC) often vanish at tree level in the Standard Model (SM) and its extensions. However with the help of extra sources of flavour violations it is possible to generate FCNC processes at loop level. Examples of this kind of sources can be the $W$ and $Z$ bosons in the SM or extra heavy scalars/fermions in the SM extensions. The high precision of the experimental measurements within the SM make these processes ideal probe for the search of new physics. To investigate the possible theory landscape we study generic extensions of the SM, but restrict ourselves to renormalisable theory to achieve calculability. In this project we examine the $\gamma$-penguin diagrams in a generic extension of the SM.

### Matching Conditions for Photon Penguin Diagrams in the Extended SM

The main purpose of this project is to study matching conditions for the Wilson coefficients of relevant operators for FCNC transitions in the generic extension of the SM. For our calculations we consider two down-type quark transition diagrams. In order to define generic form of Wilson coefficients, the extended SM is perturbatively matched on an effective theory containing only light degrees of freedom, i.e. particles much lighter than the electroweak gauge bosons. The photon dipole moment interactions in the low energy are mediated by effective operators with dimension five or higher.

The effective theory Lagrangian relevant to our calculations is

$$L_{\text{eff}} = \sum_{k=1,2} \mathcal{O}_{k}^{(3)}(\bar{L}P_{L}L) + \sum_{k=1,2} \mathcal{O}_{k}^{(4)}(\bar{L}P_{L}L).$$

The primed operators can be obtained by changing chirality sign, $P_{L,R}$ to $P_{R,L}$. The equation of motion vanishing (EOM-vanishing) operators are operators that vanish by the QCD × QED matching for photon penguin diagrams in the extended SM.

$$\mathcal{O}^{(3)}(\bar{L}P_{R}L) = \sum_{i=1}^{3} \left[\mathcal{C}_{3}^{(3)}(P_{R}L)\mathcal{C}_{i}^{(3)}(L)\mathcal{C}_{i}^{(3)}(L)\right].$$

where

$$P_{L,R} = \frac{1}{2} \left( \bar{L}P_{L}L \right) + \frac{1}{2} \left( \bar{L}P_{R}L \right).$$

The calculated values can be written as linear combinations of various functions of $x = \left( m_{F}/m_{W}\right)^{2}$.

### Conclusion

We will evaluate one-loop matching conditions for all the operators, including EOM ones, relevant to the photonic penguin diagrams in the generically extended SM with arbitrary gauge. The matching procedure gives a gauge independent result for $P_{L}$ operator which agrees with the SM calculations. The result of the current project calculations is not necessarily in the domain of flavour physics, it also can be applied to study dark matter and collider phenomenology.

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### References


