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New Physics search with $B_d^0 \to l^+ l^-$

The rare leptonic decays $B_{s,d} \to l^+ l^- (l = e, ,)$ present vital base to analyse the flavour structure of the standard model (SM) and also become potential source to dig out possible signatures of new physics (NP) beyond the SM [1]. The muonic decay $B_s \to \mu^+ \mu^-$ has been observed at the LHC as well as the upper limits of branching ratios for other $B_{s,d} \to l^+ l^-$ have been updated recently. In this work, we have studied the decay $B_d \to \mu^+ \mu^-$ with NP effect [2]. NP models involve the tree level exchange of a leptoquark or a $Z^{'}$ boson. If new non-SM particles present in the loop process or non-SM coupling mechanisms occur in the process, the rate of these decays can significantly change. Here, we have studied the decays with the contribution of heavy $Z^{'}$ boson. This model introduces additional couplings to this new heavy mediator at both tree and loop level and these couplings could modify the values of branching ratios. We have allowed the $Z^{'}$ boson to couple with the flavour changing part $b\bar{d}$ as well as with $\mu\bar{\mu}$. Including the NP couplings we have calculated the branching ratio expression for μ channel. The current experimental status of the branching ratio values for several channels of B_d^0 meson are given as [3, 4]: $B(B_d \to \mu^+ \mu^-) < (3.4 \times 10^{-10})$,$B(B_d \to e^+ e^-) < (8.3 \times 10^{-8})$, $B(B_d \to \tau^+ \tau^-) < (2.1 \times 10^{-3})$. The branching ratio expression consists of $b\bar{d}Z^{'}$ coupling term B_{db}^L and right-handed and left-handed $\mu\bar{\mu}Z^{'}$ coupling terms $B_{\mu\mu}^L$ and $B_{\mu\mu}^R$ respectively [5]. We have performed χ^2 fit to find these NP couplings using various constraints. From the best fit values we have calculated the branching ratio for the μ channel and got the same order as the experimental one. Here, we can say that as the fitting is useful for $B_d \to \mu^+ \mu^-$, it has predicted the branching ratio value correctly. We know that $Z^{'}$ boson does not behave in similar manner with all the generations of leptons and that infers the non-universality nature of $Z^{'}$ model. Due to non-universality we have to change $\mu\bar{\mu}Z^{'}$ couplings for the other two channels and then we can predict their branching ratios. So we can expect that the strategy used in this work is very fruitful in the investigation of NP as well as it will provide an interesting probe of lepton flavour violation. \linebreak

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