Implications of new physics in $\Lambda_b \to \Lambda_c l \nu_l$ decay processes.

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Abstract

- Several indications of lepton non universality ratios, $R(D^*)$, $R(J/\Psi)$ and the measurements on hadronic and τ longitudinal polarizations in $b \to c l \bar{\nu_\tau}$ processes have attracted a lot of attentions.
- In a model independent analysis, we constraint the new physics parameter space by using the chi square fitting.
- We study the implications of constrained new couplings on the observable such as branching fractions, forward-backward asymmetries, lepton non universality parameter and Λ_c and lepton longitudinal polarization fractions of the decay modes.
- We also probe whether there could be any lepton universality violation in this decay processes or not.

Introduction

- Effective lagrangian associated with the quark level transition $b \to c l \bar{\nu}_l$ is

$$\mathcal{L}_{\text{eff}} = -\frac{4\,G_F}{\sqrt{2}}\,V_{cb}\Big\{(1+V_L)\,\bar{l}_L\,\gamma_\mu\,\nu_L\,\bar{q}_L\,\gamma^\mu\,b_L + V_R\,\bar{l}_L\,\gamma_\mu\,\nu_L\,\bar{q}_R\,\gamma^\mu\,b_R$$

$$+S_L\,\bar{l}_R\,\nu_L\,\bar{q}_R\,b_L + S_R\,\bar{l}_R\,\nu_L\,\bar{q}_L\,b_R + T_L\,\bar{l}_R\,\sigma_{\mu\nu}\,\nu_L\,\bar{q}_R\,\sigma^{\mu\nu}\,b_L\Big\} + \text{h.c.} \tag{1}$$

where G_F is the Fermi constant, V_{cb} is the CKM matrix element, O_i are the dimension-six four fermion operators and $V_{L,R}, S_{L,R}, T_L$ represent the vector, scalar and tensor type NP couplings, which are zero in the SM.

- In the presence of NP, the double differential decay distribution for $\Lambda_b \to \Lambda_c l \bar{\nu}_l$ processes is

$$\frac{d\Gamma}{dq^2} = N\left(1-\frac{m_l^2}{q^2}\right)^2\left[A_1 + \frac{m_l^2}{q^2}A_2 + 2A_3 + \frac{1}{4}A_4 + \frac{4m_l}{\sqrt{q^2}}\,(A_5+A_6) + A_7\right] \tag{2}$$

Observables

- Forward-backward asymmetry parameter :

$$A_{FB}(q^2) = \left(\int_{-1}^{0} d\cos\theta_l \frac{d^2\Gamma}{dq^2 d\cos\theta_l} - \int_{0}^{1} d\cos\theta_l \frac{d^2\Gamma}{dq^2 d\cos\theta_l}\right) \Big/ \frac{d\Gamma}{dq^2} \tag{3}$$

- Longitudinal hadron and lepton polarization asymmetry parameter :

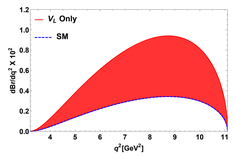
$$P_L^h(q^2) = \frac{\mathrm{d}\Gamma^{\lambda_2=1/2}/\mathrm{d}q^2 - \mathrm{d}\Gamma^{\lambda_2=-1/2}/\mathrm{d}q^2}{\mathrm{d}\Gamma/\mathrm{d}q^2} \tag{4}$$

$$P_L^\tau(q^2) = \frac{\mathrm{d}\Gamma^{\lambda_\tau=1/2}/\mathrm{d}q^2 - \mathrm{d}\Gamma^{\lambda_\tau=-1/2}/\mathrm{d}q^2}{\mathrm{d}\Gamma/\mathrm{d}q^2} \tag{5}$$

- Lepton non-universality parameter :

$$R_{\Lambda_c} = \frac{\text{Br}(\Lambda_b \to \Lambda_c \tau^- \bar{\nu}_\tau)}{\text{Br}(\Lambda_b \to \Lambda_c\, l^- \bar{\nu}_l)}\,, \quad l = e, \mu. \tag{6}$$

Results and Discussion



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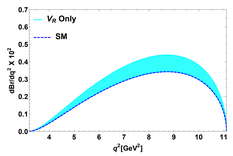

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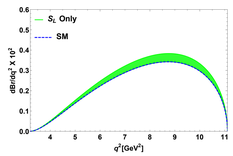

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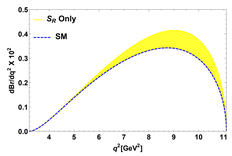

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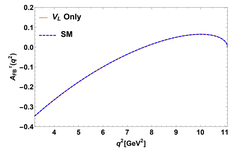
q^2 dependence of the differential decay rate in presence of V_L, V_R, S_L and $S_R$respectively.



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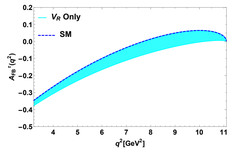

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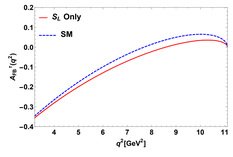

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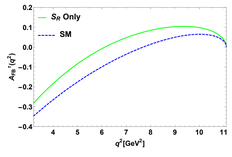

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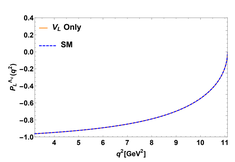
q^2 dependence of the forward backward asymmetry in presence of V_L, V_R, S_L and S_R respectively.



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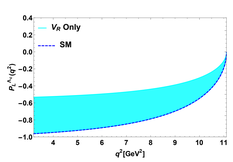

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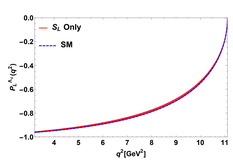

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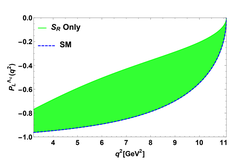

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q^2 dependence of the Longitudinal hadron polarization asymmetry in presence of V_L, V_R, S_L and S_R .

Observables	S_L coupling	S_R coupling	V_L coupling	V_R coupling
$\text{Br}(\Lambda_b \to \Lambda_c^+ \tau^- \bar{\nu}_\tau)$	1.96×10^{-2}	2.01×10^{-2}	4.76×10^{-2}	2.25×10^{-2}
A_{FB}^τ	-0.115	-0.010	-0.089	-0.150
$P_L^{\Lambda_c}$	-0.782	-0.437	-0.796	-0.441

Table 1: The predicted values of branching ratios, forward-backward asymmetries and longitudinal hadron polarization asymmetries of $\Lambda_b \to \Lambda_c \tau \bar{\nu}_\tau$ processes in the presence of only $S_{L,R}$ and $V_{L,R}$ new coefficients.

Conclusion

- We have performed a model independent analysis and explored the effect of individual complex $V_{L,R}$ and $S_{L,R}$couplings on the angular observables of baryonic $\Lambda_b \to \Lambda_c l \bar{\nu}_l$ decay processes by considering the generalized effective Lagrangian in the presence of new physics.
- The V_R and S_L couplings significantly affect all the observables and shed light on the nature of new physics.

References

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