I. INTRODUCTION

Gauge invariance of the Standard Model (SM) predicts lepton flavour universality (LFU), i.e. the couplings of leptons to electroweak bosons are independent of the generation the leptons belong to. Given two similar electroweak scattering or decay processes involving leptons from different generations, the entire difference in the branching ratios between the two processes can be attributed to the difference in the masses of the leptons. While this has been stringently verified by leptonic decays of the W and Z bosons, both neutral and charged current decays of B-mesons hint at violation of LFU. This can be probed by measuring the branching ratios, or rather, the ratio of the branching ratios, of these decays. For charged current decays of the B-meson, the ratios \( R^{\ell} \) are given by \( R^{\ell} = \frac{B(B \to D^{(*) \ell \nu})}{B(B \to D^{(*)})} (\ell = e, \mu) \) have been widely studied \([1, 20]\). The similar ratios for the neutral current decays of the B-meson that have been studied are \( R^{\mu} = \frac{B(B \to K^{*\mu\nu})}{B(B \to K^{*})} \) \([21, 45]\). Measurements of both these ratios have shown them to be different from the value expected from the SM and this has led to a lot of work trying to resolve the discrepancy using New Physics (NP) models, including SUSY- \([49, 50]\) and \(Z'\) models, as well as SUSY- \(Z'\) models, including SUSY- \([50]\). Several phenomenological models have been used to explain the discrepancies, e.g. heavy leptoquarks \([51, 52]\), \(C_{10}\) and \(Z'\) models, including SUSY- \(Z'\) models, \(\text{See Refs.} \,[23, 39, 87, 88]\) for a partial list). Our approach in this note will be to explain the anomalies using a simplified model of R-parity violating supersymmetry (RPV-SUSY) with the minimal field content i.e via sneutrinos only. Our explanation of the \(R^{\mu+}\) anomaly assumes the suppression of the branching ratio of the \(B \to K^{(*)\mu^+\mu^-}\) channel, while leaving the electron channel untouched. This is motivated by the fact that some discrepancies in angular observables like \(P_5\) can be explained by the alteration of the muonic channel. Excellent fit to all relevant observables is obtained by assuming \(C_9^\mu = -C_{10}^\mu\). Earlier, RPV-SUSY was used to explain \(B\)-anomalies with different field content \([101, 100]\). For example, the authors in Ref. \([103]\) attempt to explain the anomaly via one-loop contributions involving right-handed down type squarks \(\tilde{d}_R\). In Ref. \([104]\), the authors consider the contribution to \(b \to s \mu^+ \mu^-\) transition from the box diagrams with \(\tilde{d}_R\) and, a left-handed up type squark and sneutrino in the loop. In Ref. \([106]\), the authors focus on parameters for which diagrams involving winos give large contributions whereas Ref. \([107]\) consider diagrams involving winos only with sneutrinos. The
authors in ref. [108] explain anomaly via the diagrams involving third generation superpartners. Furthermore, it has to be noted that the RPV-SUSY scenario has enough room to accommodate a simultaneous explanation of the $R_{K^{(*)}}$, $R_{B^{(*)}}$ and the muon g-2 anomalies. This has been shown in Refs. [108] [110] [111]. In the present work, we try to address $R_{K^{(*)}}$ anomalies via the sneutrino alone, which has not been explored earlier. We demonstrate that this scenario is phenomenologically viable if certain assumptions are made. We would like to stress here that, in the present work, we do not attempt to explain $R_{K^{(*)}}$, $R_{B^{(*)}}$ and $g - 2$ anomalies simultaneously; instead, we just concentrate on the explanation of $R_{K^{(*)}}$.

The paper is arranged as follows: In Section II, we provide a short description of the RPV-SUSY model we intend to use. Then, in Section III we attempt an explanation of the discrepancy, mentioning all the assumptions we make to reach our goal. Finally, we conclude.

II. MODEL SETUP

The well known RPV superpotential in terms of superfields is given by:

$$W_{RPV} \supset \frac{1}{2} \lambda_{ijk} \bar{L}_i \tilde{L}_j E_k + \lambda'_{ijk} \bar{L}_i \tilde{Q}_j D_k + \frac{1}{2} \lambda''_{ijk} \bar{U}_i \tilde{D}_j \tilde{D}_k$$

where the hatted Latin letters denote superfields and the hatted Greek letters denote couplings. Note that $\bar{L}, \bar{Q}$ are left-handed lepton and quark chiral superfield doublets respectively, while $\bar{E}, \bar{D}$ are right-handed electron, up and down quark chiral superfield singlets. Also note that, due to the anti-symmetric $SU(2)$ product in SUSY, the $\lambda$ coupling is anti-symmetric in its first two indices.

Since proton decay positivity is a stringent constraint on the RPV couplings, we have to set either the lepton-number violating couplings ($\lambda$) or the baryon-number violating couplings ($\lambda''$) to zero [112]. In order to explain the $R_{K^{(*)}}$ anomaly, we keep $\lambda'$ non-zero and set $\lambda''$ to zero. Thus, the superpotential simplifies to contain only the $\lambda$ and $\lambda'$ terms. We assume that all the coloured SUSY particles – the squarks and gluino – are very heavy, as are the wino and Higgsino. Only the slepton doublet is assumed to be light enough to contribute to our process and the sneutrinos are taken to be degenerate in masses. Thus, we can write the RPV Lagrangian in terms of ordinary fields comprising SM and SUSY particles.

$$\mathcal{L}_{RPV} \supset \frac{1}{2} \lambda_{ijk} \left[ (\bar{L}_i \tilde{L}_j \bar{R}_k L + \bar{L}_j \tilde{L}_k \bar{R}_i L + \bar{L}_k \tilde{L}_i \bar{R}_j L) 
- (\bar{L}_i \tilde{L}_j \bar{R}_k L + \bar{L}_j \tilde{L}_k \bar{R}_i L + \bar{L}_k \tilde{L}_i \bar{R}_j L) \right] + \lambda'_{ijk} \left[ (\bar{L}_i \tilde{D}_j \bar{D}_k L + \bar{L}_j \tilde{D}_k \bar{D}_i L + \bar{L}_k \tilde{D}_i \bar{D}_j L) 
- \lambda''_{ijk} \left( \bar{L}_i \tilde{D}_j \bar{D}_k L + \bar{L}_j \tilde{D}_k \bar{D}_i L + \bar{L}_k \tilde{D}_i \bar{D}_j L \right) \right] + \text{H.c.}$$

The fields with a tilde above them are SUSY fields, while the rest are SM fields. Note that couplings are defined in mass basis in Eqn. 2. For reviews on the RPV-SUSY, see Refs. [113] [118].

Here, we present a scenario where we keep $\lambda$ and $\lambda'$ both term non-zero and we found that keeping only sneutrino to be light can also address the $R_{K^{(*)}}$ anomaly. We could have chosen to keep other particles light and do a scan to find the correct parameter space. But, this has been considered in Refs. [108]. So, in this work, we focus on the part of parameter space where only sneutrinos explain the anomaly. This is different from Ref [107] where only $\lambda'$ couplings were considered and thus, winos and sneutrinos were both required to be light.

III. $b \to s \mu^+ \mu^-$ PROCESS

The mediation of $\tilde{\nu}$ can contribute to $b \to s \mu^+ \mu^-$ processes at loop level via the photonic penguin diagram and a box-diagram, shown in Fig. 1. After integrating out $\tilde{\nu}$, the contributions to the $B$-meson decays can be described by shifts in the Wilson coefficients of effective operators in the effective Hamiltonian:

$$\mathcal{H}_{\text{eff}} = -\frac{4G_F}{\sqrt{2}} V_{tb}^* V_{tb} \frac{\alpha}{4\pi} \left[ C_S^f O_S^f + C_7 O_7 + \sum_{i=9,10} (C_i^f)(O_i^f) \right]$$

with

$$O_{S(41)}^f = (\bar{s}_R P(L)b)(\bar{\ell}_f \ell_f)$$
$$O_{S(10)}^f = (\bar{s}_R P(L)b)(\bar{\ell}_f \gamma^5 \ell_f)$$
$$O_{10}^{f(91)} = (\bar{s}_R P(L)b)(\bar{\ell}_f \gamma^a \gamma_5 \ell_f)$$

In the SM, the value of the coefficients are [119]:

$$C_9^f_{\text{SM}} = 4.211; \quad C_{10}^f_{\text{SM}} = -4.103$$
$$C_7_{\text{SM}} = -0.304; \quad C_8^f_{\text{SM}} \simeq 0$$

In order to explain the anomaly, using global fits, the New Physics contribution to $C_9$ and $C_{10}$ needs to be 58 (see also Ref. [56] [100] [120]):

$$\delta C_9^f = -\delta C_{10}^f = -0.41 \pm 0.09$$

We look at the different contributions to these Wilson coefficients and important constraints one-by-one. Our goal is to explain the requirement laid down in Eqn. 8 without violating any of the constraints.

Scalar Operators: The scalar operator $O_S^f$ contributes to the $b \to s \ell^+ \ell^-$ process at the tree level. It induces the following change in the scalar Wilson coefficient:

$$\delta C_S^f = \frac{\sqrt{2} \pi}{G_F V_{tb}^* V_{tb}} \sum_i \lambda_{23}^{i*} \lambda_{22}^{i} \left( \frac{m_{\tilde{\nu}}}{m_{\tilde{\nu}}} \right)$$

It is known that the scalar operators involving muons are unable to provide solutions to these anomalies (refer to
Eqn. 9 is extremely small or the mass of the sneutrino is scalar operators. Thus, either the coupling constant in Ref. [25]. Moreover, the branching ratio of $B_s \to \mu^+ \mu^-$ puts a strong constraint on the Wilson coefficient of the scalar operators. Thus, either the coupling constant in Eqn. 9 is extremely small or the mass of the sneutrino is very large. We assume that the (sum of the) couplings is very small.

**The contribution to $C_9$ and $C_{10}$**

As discussed earlier, global fits of all the relevant data on rare $B$ decays as well as $R_{K^{(*)}}$ favor a BSM picture which is characterized by $C_9^{SM} = -C_{10}^{SM}$. This result also requires BSM in the primed coefficients to be subdominant. The present scenario, however, generates contributions to $C_9^{prim} = -C_{10}^{prim}$ due to mediation of $\tilde{u}_L$ at tree level and $\tilde{u}_L$ at loop level (Box diagram). These lead to an anti-correlated effect in $R_K$ and $R_{K^{(*)}}$ [25] and it is necessary to avoid this contribution. There are two ways to implement this: i) by postulating that only one generation of the right-handed quarks can couple to the other two fields, i.e. there is only one value of $k$ in $\lambda_{ijk}^{SM}$ [104, 106], or, ii) by postulating that the squarks are extremely heavy and don’t contribute to this process. We already have chosen squarks to be heavy because of which the tree-level contribution is very small. To avoid the box diagram contribution, the first option is imperative. Therefore, we utilize the first option and choose $k = 3$.

This leads to an important consequence. The tree-level contribution to $B_s \to \bar{B}_s$ via sneutrino exchange goes to zero, since the coupling involved in this process is of the form $\sum \lambda_{i32}^* \lambda_{23}$. This is zero since all $\lambda_{i32}$ are zero consistent with the postulate above.

**The Box and Penguin contribution to $C_9$ and $C_{10}$**

The contributions of the box [108] and penguin [107] diagrams, shown in Fig. 1 to $C_9^{prim}$ and $C_{10}^{prim}$ Wilson coefficient are given by:

$$\delta C_9^{prim} = \frac{\sqrt{2} \lambda_{i33}^* \lambda_{i23} \lambda_{lk} \lambda_{kt} \ell m_f}{8 i G_F V_{tb} V_{ts}^* D_2 \left( m_{\tilde{u}}^2, m_{\tilde{u}}^2, m_{\tilde{d}}^2, m_{\ell}^2 \right)}$$

$$\delta C_{10}^{prim} = \frac{\sqrt{2} \lambda_{i33}^* \lambda_{i23} \lambda_{lk} \lambda_{kt} \ell m_f}{128 \pi G_F V_{tb} V_{ts}^* m_{\tilde{u}}^2}$$

(10)

$$\delta C_9^{prim} = \frac{\sqrt{2} \lambda_{i33}^* \lambda_{i23} \lambda_{lk} \lambda_{kt} \ell m_f}{36 G_F V_{tb} V_{ts}^* m_{\tilde{u}}^2 \left( \log \frac{m_{\tilde{u}}^2}{m_{\ell}^2} \right)}$$

(11)

where $\ell = e, \mu, \tau$ (\(\equiv 1, 2, 3\)) and $D_2[...]$ is the four-point Passarino-Veltman function for which the external momenta have been ignored. Note that the penguin contribution is lepton universal as opposed to the box diagram. Allowed the proper value of the couplings, these contributions should be able to explain the $R_{K^{(*)}}$ anomaly. The constraints on the value of the couplings come primarily from two sources – the $b \to s \gamma$ process and the $B_s - \bar{B}_s$ oscillations.

**Photonic penguin contribution to $C_7$**

The penguin diagram also leads to the effective operator $O_7$. The contribution to the $C_7$ coefficient is given by [107].

$$\delta C_7^{penguin} = \frac{\sqrt{2} \lambda_{i33}^* \lambda_{i23} \lambda_{lk} \lambda_{kt} \ell m_f}{144 G_F V_{tb} V_{ts}^* m_{\tilde{u}}^2}$$

(12)

Given that the branching ratio of the process $b \to s \gamma$ is extremely well-measured by experiments, it provides useful limits on the contribution of the penguin diagram to the $C_7$ coefficient. This becomes all the more important since the RPV coupling in Eqn. 12 is the exact coupling which appears in Eqn. 11.

From the world average of the measurement of $B(B \to X_s \gamma)$, we have from HFAG [121]

$$B(B \to X_s \gamma)|_{exp} = (3.27 \pm 0.14) \times 10^{-4}$$

(13)

(for $E_\gamma > E_0 = 1.6 \text{ GeV}$) while the SM prediction is [122]

$$B(B \to X_s \gamma)|_{SM} = (3.36 \pm 0.23) \times 10^{-4}$$

(14)

This tight constraints leaves little room for NP contributions to $C_7$. According to Ref. [123], the real part of $C_7$ can be modified by

$$\delta C_7 \in [-0.018, 0.012] \text{ at } 1\sigma$$

$$\delta C_7 \in [-0.032, 0.027] \text{ at } 2\sigma$$

(15)

From this, we get the following constraint:

$$-1.81 \times 10^{-6} \leq \frac{\lambda_{i33}^* \lambda_{i23}}{(m_{\tilde{u}}/\text{GeV})^2} \leq 2.15 \times 10^{-6}$$

(16)

Based on various collider searches of RPV-SUSY models in which the sneutrino is the NLSP and the $\chi^0_1$ is the LSP, we assume $m_{\tilde{u}} = 1 \text{ TeV}$ [124]. Note that the value
FIG. 2: The Feynman diagram for $B_s - \bar{B}_s$ mixing.

of $m_\rho$ occurs only in the logarithm term of Eqn. (11) and thus the bound on $\delta C_9^{\text{penguin}}$ is not sensitive to the exact value of $m_\rho$ (see conclusion for more details on the masses of sneutrinos). Using the 1$\sigma$ bound from Eqn. (16) in Eqn. (11) the contribution of $\delta C_9^{\text{penguin}}$ becomes

$$-1.68 \leq \delta C_9^{\text{penguin}} \leq 1.41$$

(17)

Constraint from $B_s - \bar{B}_s$ mixing: The box diagram also contributes to $B_s - \bar{B}_s$ mixing as shown in Fig. 2. Following the UTfit collaboration prescription [125], we can parameterize the full (SM + NP) oscillation amplitude to be:

$$C_{B_s} e^{2i\phi_{B_s}} = \frac{\langle B_0 \mid H_{\text{eff}} \mid B_s \rangle^*}{\langle B_0 \mid H_{\text{eff}}^\dagger \mid B_s \rangle}$$

(18)

The RPV contribution can then be written as

$$C_{B_s} e^{2i\phi_{B_s}} = 1 + \frac{\sum_i \lambda_{i33}^* \lambda_{i23}^*}{32 M_0^2 G_F^2 S_0(x_t) (V_{tb} V_{ts}^*)^2} \frac{m_\rho^2}{m_\rho^2}$$

(19)

where $S_0(x)$ is the Inami-Lim function, which arises from the SM contribution, and $x_t = (m_t^2/M_W^2)$, where $m_t$ and $M_W$ are the masses of the top and the W-boson respectively. We take $m_t = 172.76$ GeV, we get $S_0(x_t) = 2.5264$. From this we get,

$$C_{B_s} = 1 + \frac{\sum_i \lambda_{i33}^* \lambda_{i23}^*}{32 M_0^2 G_F^2 S_0(x_t) (V_{tb} V_{ts}^*)^2} \frac{m_\rho^2}{m_\rho^2}$$

$$= 1 + 8.796 \times 10^{-3} \frac{\sum_i \lambda_{i33}^* \lambda_{i23}^*}{(m_\rho/\text{GeV})^2}$$

(20)

The constraint on the value of $C_{B_s}$, defined in Eqn. (15) following the UTfit collaboration prescription [125], is $C_{B_s} = 1.110 \pm 0.090$ and $\phi_{B_s} = (0.42 \pm 0.89)$. Given that the SM values of the parameters are $C_{B_s} = 1$, $\phi_{B_s} = 0^\circ$, the NP contribution should be $C_{B_s}^{\text{NP}} = 0.11 \pm 0.09$. To be conservative, we work with only upper limit and thus, we get the following constraints on

$$\left( \frac{\sum_i \lambda_{i33}^* \lambda_{i23}^*}{(m_\rho/\text{GeV})^2} \right)^2 \leq 2.27 \times 10^{-8} \left( \frac{m_\rho/\text{GeV}}{m_\rho/\text{GeV}} \right)^2$$

(21)

$$- 1.5 \times 10^{-4} \left( \frac{m_\rho/\text{GeV}}{m_\rho/\text{GeV}} \right) \leq \frac{\sum_i \lambda_{i33}^* \lambda_{i23}^*}{(m_\rho/\text{GeV})^2} \leq 1.5 \times 10^{-4} \left( \frac{m_\rho/\text{GeV}}{m_\rho/\text{GeV}} \right)$$

(22)

For $m_\rho = 1$ TeV, the constraint arising from $B_s - \bar{B}_s$ mixing measurement is much stronger than that from the measurement of $B(b \to s \gamma)$. For $m_\rho = 1$ TeV, we use Eqn. (22) in Eqn. (11) to get the following constraint on $\delta C_9^{\text{penguin}}$ from $B_s - \bar{B}_s$ mixing:

$$-0.12 \leq \delta C_9^{\text{penguin}} \leq 0.12$$

(23)

which far supersedes the weaker constraint derived in Eqn. (17). We should treat it as a phenomenological constraint which should always be satisfied by the corresponding combination of $\lambda'$ couplings. However, this contribution is lepton flavor universal and leads to non-zero $\delta C_9^{\text{penguin}}$ as well. Thus, to prevent a contribution to $C_9$, consistent with our assumption, we postulate the relation among the $\lambda'$ couplings to follow the condition:

$$\sum_i \lambda_{i33} \lambda_{i23}^* \approx 0.$$  

(24)

In this way, the contributions from penguin diagrams to $C_9$ (Eqn. (11)) and $C_7$ (Eqn. (12)) vanish (if the sneutrinos are degenerate in mass), leaving only the contribution from the box diagram. In view of Eqn. (24) the NP contribution to $b \to s \bar{d} \nu \nu$ processes, via exchange of sneutrinos and $Z-$boson in the penguin diagram, also disappears. Potential constraints on the couplings can also arise from the box diagram involved in $D^0 - \bar{D}^0$ oscillations; however, the coupling combination involved in that process is $|\lambda_{113} \lambda_{123}^*|^2$, which is not the combination we consider. The couplings involved in the two processes are not correlated, thus, we do not consider this constraint in our analysis.

Explaining the $R_{K^{(*)}}$ anomaly: Using the assumption in Eqn. (24) the values of the couplings and the mass of the sneutrinos that explain $R_{K^{(*)}}$ within 1$\sigma$ are plotted in Fig. 3. From this, we conclude that the box diagram alone can provide a phenomenologically viable explanation for both the $R_K$ and $R_{K^{*}}$ anomalies.

There are certain conditions and caveats, however, which need to be stated. Firstly, our solution requires at least two generations of slepton doublets, unlike in Ref. 108 where only the third generation slepton doublet was considered. Secondly, we require $\delta C_{e^r, \text{box}} = 0$, which can be achieved by setting the corresponding coupling to zero. Doing this doesn’t affect the contribution of the box diagram to the $\delta C_{9, \text{box}}$ coefficient. Thirdly, from Fig. 3 it is clear that in large parts of the parameter space which explain the anomalies, the value

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1 Strictly speaking, this situation will be realized if any one generation is involved, not necessarily the third.

2 It has to be emphasized here that this solution also takes into account other constraints like those arising from $B_s - \bar{B}_s$ and $B_s \to \mu^+ \mu^-$ process. This is because the best fit value of the $\delta C_9$ coefficient comes from global fits, which takes into account these constraints.
The corresponding couplings are large which means that many of the couplings also contribute to various decays such as $\ell_i \to \ell_j \gamma$, $B \to \ell_i \nu_j$, $B \to \ell_i \ell_j$ etc. However, we have checked that the constraints on the couplings arising from these processes can be easily accommodated by keeping certain couplings to be small, while still explaining the $R_{K^{(*)}}$ anomaly. These constraints are discussed in detail in the Appendix. A summary of the low energy constraints are given in Table II.

| Process | RPV coupling involved | Constraint on coupling so that contribution vanishes |
|---------|-----------------------|--------------------------------------------------|
| $b \to e\tau \nu$ | $\lambda_{23}^i \lambda_{ij3}$ | $\lambda_{ij3} = 0$ |
| $b \to u\tau \nu$ | $\lambda_{13}^i \lambda_{ij3}$ | |
| $\tau \to \mu \gamma$ | $\lambda_{jj3} \lambda_{ij2} + \lambda_{13k} \lambda_{2k3}$ | Zero because of $\lambda_{ij3} = 0$ |
| $\mu \to e\gamma$ | $\lambda_{jj2} \lambda_{ij1} + \lambda_{12j} \lambda_{11j}^*$ | Zero because of $\lambda_{ij2} = 0$ |
| $Z \to e_R e_R$ | $\lambda_{jj1} \lambda_{1j2}$ | Zero because of above choices |
| $Z \to e_L e_L$ | $\lambda_{11j} \lambda_{12j}^*$ | Zero because of above choices |
| $Z \to e_L \mu_L$ | $\lambda_{11j} \lambda_{12j}^*$ | Zero because of above choices |
| $Z \to \mu_L \mu_L$ | $\lambda_{12j} \lambda_{13j}^*$ | |
| $Z \to \ell_L \ell_L$ | $\lambda_{11j} \lambda_{13j}^*$ | With $\lambda_{ij2} = 0$; $\lambda_{121} \lambda_{321} \lesssim 71.0$ (for $m_\nu = 1 \text{ TeV}$) |
| $Z \to \mu_L \tau_R$ | $\lambda_{12j} \lambda_{13j}^*$ | Zero because of above choices |

TABLE II: Summary of the low energy constraints relevant to the couplings involved in the $R_{K^{(*)}}$ process. While the explicit limits on the couplings have been calculated in the Appendix, the table lists out the condition on the couplings such that the contribution to the respective processes is zero. Note that this always leaves $\lambda_{33}^i \lambda_{23}^j \lambda_{122} \lambda_{222}$ non-zero, which contributes to $b \to s\mu^+ \mu^-$ and thus to $R_{K^{(*)}}$.

In order to illustrate the fact that the low energy constraints do not affect our explanation of $R_{K^{(*)}}$, we can consider two benchmark scenarios.

**Case 1: Constrained benchmark:** In this scenario, the RPV contribution to all low energy processes is zero and this can be achieved if the conditions outlined in the third column of Table II are all assumed. Even in this highly constrained scenario, the coupling product in Eqn. 11 becomes

$$\sum_{i,k,m} \lambda_{333}^j \lambda_{233}^i \lambda_{13m}^j \lambda_{kim} \sim \lambda_{123}^j \lambda_{121} \lambda_{13m} \lambda_{kim} \sim \lambda_{123}^j \lambda_{121} \lambda_{13m} \lambda_{kim} \sim \lambda_{123}^j \lambda_{121} \lambda_{13m} \lambda_{kim}$$

(25)

According to Ref. [126], $\lambda_{321}$ and $\lambda_{121}$ can have magnitude less than unity. So, we can safely assume the product, $\lambda_{321} \lambda_{121}$, to be small in comparison to $|\lambda_{321}|^2$ or $|\lambda_{121}|^2$, just for our convenience and we get

$$\sum_{i,k,m} \lambda_{333}^j \lambda_{233}^i \lambda_{13m}^j \lambda_{kim} \sim \lambda_{123}^j \lambda_{121} \lambda_{13m}^j \lambda_{kim} \sim \lambda_{123}^j \lambda_{121} \lambda_{13m}^j \lambda_{kim}$$

(26)

Note that by keeping the product, $\lambda_{321} \lambda_{121}$ non-negligible would increase the required parameter space. Thus, our approach is conservative.

For $m_\nu \sim 1 \text{ TeV}$, we can choose

$$\lambda_{333}^j \sim 0.02, \quad \lambda_{233}^j \sim 3.5$$
$$\lambda_{333} \sim 3.5, \quad \lambda_{233} \sim 3.5$$

(27)

with squark masses fixed around 100 TeV. $\lambda_{133}$ coupling contributes to Majorana mass for the neutrinos, which provides a very strong constraint. The coupling scales as the square-root of the down type squark mass [126].

FIG. 3: Graph showing the couplings and the mass of the sneutrino required so that the contributions from the box diagram can explain the $R_{K^{(*)}}$ anomaly. It is assumed that the entire contribution to $\delta C_9^\nu$ is due to the Box diagram.

of the couplings is large which means that many of the corresponding $\lambda$ and $\lambda'$ couplings might themselves be $\mathcal{O}(1)$. This can potentially be a problem as these couplings also contribute to various decays such as $\ell_i \to \ell_j \gamma$, $B \to \ell_i \nu_j$, $B \to \ell_i \ell_j$ etc. However, we have checked that the constraints on the couplings arising from these processes can be easily accommodated by keeping certain couplings to be small, while still explaining the $R_{K^{(*)}}$
of $\delta C_9$. We choose $\lambda_{ij3} = 0$ to evade strong constraints from $b \to c\tau\nu$ whereas $\lambda_{ij1}$ should be small in comparison to $\lambda_{ij2}$ to avoid $\mu \to e\gamma$ limits. We keep $\lambda_{3ij}$ so small that we can avoid bounds from $\mu_L \to e_L\gamma$, $\tau_L \to \mu_L\gamma$, $Z \to e_L\mu_L$ and $Z \to \mu_L\tau_L$. To this end, we get contour regions on $\lambda - \lambda'$ plane addressing $R_{K^{(*)}}$ anomaly for different sneutrino masses in Fig. 4. Note that, for this case, the relevant low energy constraints are due to the $\mu_R \to e_R\gamma$ $Z \to \mu_R \mu_R$ and $Z \to e_R\tau_L$ processes. Out of these, the strongest constraint is due to $\mu_R \to e_R\gamma$, which is what is plotted.

Both of the results above imply that it is possible to evade the low energy constraints while still continuing to explain $R_{K^{(*)}}$ in our scenario.

IV. CONCLUSION

Chinks in the seemingly impregnable armor of the Standard Model (SM) are rare, but one of the most promising ones appear from the measurement of the ratio of the branching ratios of semi-leptonic decays of the $B$-mesons, like $R_{D^{(*)}}$ or $R_{K^{(*)}}$. A recent measurement of the ratio $R_K$ by the LHCb collaboration announced at the 2021 Moriond Conference strengthens the existing discrepancy in $R_K$ with the SM from 2.5σ earlier to 3.1σ now. Several theoretical attempts have been made to explain this within some extension of the SM. We attempt the same using a simplified RPV-SUSY framework, using only lepton number-violating couplings, in which all particles except left-handed slepton doublet are too heavy to significantly contribute to the $b \to s\tau\nu$ ($\ell = e, \mu$) process. We show that even with this minimal extension, it is possible to explain the anomaly with the box diagram contribution alone, while also respecting all relevant constraints. We stress that our proposed solution is by no means the only solution to the problem, but that it is a phenomenologically plausible one. Specific values of couplings are considered which are compatible with these assumptions, without delving into an explanation of their particular value.

The various limits derived on the RPV-SUSY couplings and thus on the relevant Wilson coefficients of the effective operators crucially depend on the mass of the sneutrino. Collider searches in the RPV-SUSY scenario where the $\tilde{\nu}$ is the NLSP and the $\chi^0_1$ is the LSP put the limits at $\sim 1$ TeV [124]. Additionally, the values of the $\lambda$ and $\lambda'$ couplings are dependent on and scales appropriately with the mass of the squarks. Since the squarks in our minimal model are very heavy, there is no upper limit on the values of the RPV couplings, apart from those arising possibly from perturbative unitarity. More stringent lower bounds on sneutrino masses are obtained from studying the direct production of the $\tilde{\nu}$ in $pp$ collisions, which then decay exclusively to lepton flavour violating channels such as $e\mu, \mu\tau$ and $e\tau$. Collider searches for this signal in Ref. [127–130] assume sneutrinos to be degenerate and rules out their existence for mass less
than 3.4 TeV, 2.9 TeV, 2.6 TeV for tau sneutrino decaying to $\ell\mu\gamma$, or $\mu\tau$ respectively, with $\lambda_{11}^{\ell}_{ij}\lambda_{12}^{*}\lambda_{12}^{*}\lambda_{22}^{*}$ = 0.11 and $\lambda_{13}^{\ell}_{ij}\lambda_{13}^{*}\lambda_{13}^{*}\lambda_{23}^{*}$ = 0.07. Note, however, that these analyses assume $Br(\tilde{\nu} \rightarrow \ell\ell') = 1.0$. If sneutrino is kinematically allowed to decay overwhelmingly into a neutralino ($\tilde{\chi}^0$) and SM neutrino, the aforementioned constraints get relaxed and limits on $m_{\nu}$ comes to be about 1 TeV \cite{31,32}. While we have used the more relaxed mass limit in our calculations, it is perfectly possible to use the larger mass limit and still arrive at a plausible explanation.

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**Appendix A: Tree-level contribution to $b \rightarrow c\tau\nu$**

The RPV coupling that goes into the $R_{K(\tau)}$ ratios is the combination:

$$R_{K(\tau)} \propto \lambda_{13}^{\ell}_{ij}\lambda_{13}^{*}\lambda_{12}^{*}\lambda_{22}^{*}\lambda_{22}^{*}\lambda_{2m}^{*}\lambda_{2m}^{*} \quad (A1)$$

where $i, k \neq 2$ owing to the antisymmetry in the first two indices of the $\lambda$ couplings.

**Assume : $\lambda_{13} = 0$** \quad (A2)

This is to make the tree-level contributions to $b \rightarrow c\ell\tau\nu$ or $B_{u/c} \rightarrow \tau\nu$ vanish. The amplitude of this process is proportional to the RPV coupling

$$A^{b \rightarrow c}_{tree} \propto \lambda_{13}^{\ell}_{ij}\lambda_{13}^{*}\lambda_{13}^{*}\lambda_{13}^{*}\lambda_{12}^{*}\lambda_{22}^{*}\lambda_{22}^{*}\lambda_{2m}^{*}\lambda_{2m}^{*} \quad (A3)$$

which vanishes with the assumption in Eqn. A2

**Appendix B: Charged Lepton Flavour Changing Processes**

RPV couplings contribute to processes of the type $\ell_i \rightarrow \ell_j\gamma$. We shall explore these and try to calculate a bound on the contributions.

![Feynman diagrams showing the process $\tau \rightarrow \mu\gamma$ for both handedness of the external leptons. The diagrams for $\mu \rightarrow e\gamma$ and $\tau \rightarrow e\gamma$ are similar with appropriate changes of the couplings.](image)

**1. $\tau \rightarrow \mu\gamma$ process**

The process $\tau \rightarrow \mu\gamma$ can involve both right handed and left handed charged leptons. We have to treat them separately, since the RPV couplings involved in them are different.

**Right handed current:**

The Feynman diagrams for this process are given on the top row of Fig. 5. For left-handed leptons, there is a non-zero contribution. The amplitude for these diagrams are proportional to

$$A^{(1)}_{\tau \rightarrow \mu\gamma} \propto \frac{\lambda_{12}^{\ell}_{ij}\lambda_{13}^{*}\lambda_{13}^{*}\lambda_{13}^{*}\lambda_{13}^{*}\lambda_{13}^{*}\lambda_{13}^{*}\lambda_{13}^{*}\lambda_{13}^{*}}{m_{\mu}\ell_{i}} \quad (B1)$$

$$A^{(2)}_{\tau \rightarrow \mu\gamma} \propto \frac{\lambda_{12}^{\ell}_{ij}\lambda_{13}^{*}\lambda_{13}^{*}\lambda_{13}^{*}\lambda_{13}^{*}\lambda_{13}^{*}}{m_{\mu}\ell_{i}} \quad (B2)$$

Evidently both of these contributions vanish due to the assumption in Eqn. A2. Thus, for the process $\tau \rightarrow \mu\gamma$ there is no contribution from right-handed charged leptons.

**Left handed current:**

The diagrams for this process are given in the bottom row of Fig. 5. For left-handed leptons, there is a non-zero contribution. The amplitude is proportional to

$$A^{(1)}_{\tau \rightarrow \mu\gamma} \propto \frac{\lambda_{13}^{\ell}_{ij}\lambda_{12}^{*}\lambda_{12}^{*}\lambda_{12}^{*}}{m_{\mu}\ell_{i}} \quad (B3)$$

$$A^{(2)}_{\tau \rightarrow \mu\gamma} \propto \frac{\lambda_{13}^{\ell}_{ij}\lambda_{12}^{*}\lambda_{12}^{*}}{m_{\mu}\ell_{i}} \quad (B4)$$

The RPV coupling, written explicitly, is

$$\lambda_{13k}\lambda_{12k}^{*} = \lambda_{131}\lambda_{121}^{*} + \lambda_{132}\lambda_{122}^{*}$$

Note that whereas the value of $k$ in the first line cannot be 3 because of Eqn. A2, the value of $i$ in the second line can only be 1 because of the anti-symmetry in the first two indices of the $\lambda$ coupling.
The decay width of this process then is

$$\Gamma(\tau \to \mu \gamma)|_{\text{RPV}} \approx \frac{\alpha_emN_\tau^5}{256\pi^4} \kappa^2 = 5.186 \times 10^{-6} \kappa^2 \text{ GeV}^5$$

(B6)

where

$$\kappa = \frac{1}{m_l^2} (\lambda_{131}^\dagger \lambda_{121}^* + \lambda_{132}^\dagger \lambda_{122}^*) \equiv \frac{C(\lambda)}{m_l^2}$$

(B7)

For a slepton or sneutrino mass of about 1 TeV, this gives,

$$\Gamma(\tau \to \mu \gamma)|_{\text{RPV}} = 5.19 \times 10^{-18} |C(\lambda)|^2 \text{ GeV}$$

(B8)

The total decay width is $\Gamma(\tau \to \mu \gamma) = 4.0 \times 10^{-13} \text{ GeV}$. Thus, the branching ratio is given by

$$\mathcal{B}(\tau \to \mu \gamma)|_{\text{RPV}} = 1.30 \times 10^{-5} |C(\lambda)|^2$$

(B9)

The experimental limit on the branching ratio is $\mathcal{B}(\tau \to \mu \gamma) < 4.4 \times 10^{-8}$ \cite{133}. This means that we can avoid this bound if $|C(\lambda)| < 0.06$. This is quite achievable with the current limits on the RPV couplings. We can however completely eliminate this contribution by postulating that the only non-zero LLE RPV couplings are of the form $\lambda_{1ij}$, since this is what is required for our explanation of $R_{K(\pi)}$.

2. $\mu \to e\gamma$ process

As with the previous process, this can also involve both right and left handed charged leptons. The diagrams are similar and the amplitudes are proportional to

$$A_{\mu e \to \mu e \gamma}^{(1)} \propto \frac{\lambda_{122}^\dagger \lambda_{121}^*}{m_{l_i}^2}$$

(B10)

$$A_{\mu e \to \mu e \gamma}^{(2)} \propto \frac{\lambda_{122}^\dagger \lambda_{121}^*}{m_{l_i}^2}$$

(B11)

$$A_{\mu l \to \mu l \gamma}^{(1)} \propto \frac{\lambda_{122}^\dagger \lambda_{121}^*}{m_{\nu_{l_i}}^2}$$

(B12)

$$A_{\mu l \to \mu l \gamma}^{(2)} \propto \frac{\lambda_{122}^\dagger \lambda_{121}^*}{m_{\nu_{l_i}}^2}$$

(B13)

The contribution to the decay width of the process due from RPV-SUSY is given by

$$\Gamma(\mu \to e\gamma)|_{\text{RPV}} \approx \frac{\alpha_emN_\mu^5}{256\pi^4} \kappa^2 = 4.0 \times 10^{-12} \kappa^2 \text{ GeV}^5$$

(B14)

where, given $m_\nu \approx m_l$,

$$\kappa = \frac{1}{m_l^2} [\lambda_{122}^\dagger \lambda_{121}^* - \lambda_{132}^\dagger \lambda_{131}^*]$$

$$= \frac{1}{m_l^2} [\lambda_{321}^\dagger \lambda_{311}^* + \lambda_{322}^\dagger \lambda_{312}^* - \lambda_{122}^\dagger \lambda_{121}^* - \lambda_{132}^\dagger \lambda_{131}^* - \lambda_{212}^\dagger \lambda_{211}^* - \lambda_{232}^\dagger \lambda_{231}^* - \lambda_{132}^\dagger \lambda_{131}^* - \lambda_{232}^\dagger \lambda_{231}^* - 2\lambda_{212}^\dagger \lambda_{121}^* - 2\lambda_{232}^\dagger \lambda_{231}^* - 2\lambda_{312}^\dagger \lambda_{311}^*]$$

$$= \frac{C(\lambda)}{m_l^2}$$

(B15)

Considering the mass of the sleptons $m_l \approx 1 \text{ TeV}$, we have

$$\Gamma(\mu \to e\gamma)|_{\text{RPV}} \approx 4.0 \times 10^{-24} |C(\lambda)|^2 \text{ GeV}$$

(B17)

Given that the total decay width is $\Gamma_{\mu e} = 3.0 \times 10^{-19} \text{ GeV}$, this gives us a branching ratio of:

$$\mathcal{B}(\mu \to e\gamma) \approx 1.33 \times 10^{-5} |C(\lambda)|^2$$

(B18)

The limit on the branching ratio from the MEG collaboration is $\mathcal{B}(\mu \to e\gamma) < 4.2 \times 10^{-13}$ \cite{134}. This puts strong bounds on the possible values of the coupling. Naively, one can say that each of the lambda couplings is $\mathcal{O}(10^{-2})$. Looking at the couplings involved (Eqn. B15), we find that only the $\lambda_{122}$ coupling needs to be large for our explanation of $R_{K(\pi)}$. We can easily postulate that the only couplings which are non-zero are of the form $\lambda_{122}$. This will be enough to explain the anomalies in our scenario. This postulate will also mean that the value of $\kappa$ in Eqn. B15 is zero, which forbids this decay via RPV couplings.

Appendix C: $Z \to \ell_i \ell_j$

The one-loop diagrams for the decay of the $Z$-boson to dileptons (including those of different flavours) in the RPV-SUSY framework are given by:

For right-handed final state leptons, the matrix element can be written as

$$\mathcal{M} = \bar{u}(p_2)\lambda_{knj} \int \frac{d^2q}{(2\pi)^2} \frac{1}{q^2 - m_{k}^2} \frac{g - p_2 - m_{n}^2}{(q - p_2)^2 - m_{m}^2}$$

$$\times g_L\gamma^\mu P_L(q + p_1 - m_{m}^2)\lambda_{knj}v(p_1)\epsilon_\mu(p_1 + p_2)$$

$$= g_L\lambda_{knj} \lambda_{knj} v(p_1 + p_2) \bar{u}(p_2) \int \frac{d^2q}{(2\pi)^2} \frac{1}{q^2 - m_{k}^2}$$

$$\times \sum_{\ell_i} \frac{Tr[\gamma^\mu(\ell_i - m_{\ell_i}^2)]}{((q - p_2)^2 - m_{m}^2)((q + p_1)^2 - m_{m}^2)} v(p_1)$$
where \( \text{Tr}_D \) is the Dirac trace. Using Package-X\([135]\) to evaluate the trace, we have
\[
\mathcal{M} = g_L \lambda_{\nu_3} \lambda_{km\ell} \epsilon_\mu(p_1 + p_2) \bar{u}(p_2) \int \frac{d^Dq}{(2\pi)^D} \frac{1}{q^2 - m^2_{\nu}} \frac{-2m_{m_i}(p_{1\mu} - p_{2\mu} - 2q_\mu)}{((q - p_2)^2 - m^2_{\nu})(q + p_1)^2 - m^2_{\nu}} v(p_1)
\]
(Evaluating the loop integral only gives us:
\[
L = -2m_{m_i} \left[ p^\mu_1 - p^\mu_2 \right] C_0 \left( m_{\nu}, m_{m_i}, m_{m_i}; m_Z, m_l, m_{l_j} \right) + 2p^\mu_1 C_1 \left( m_{\nu}, m_{m_i}, m_{m_i}; m_Z, m_l, m_{l_j} \right) - 2p^\mu_2 C_2 \left( m_{\nu}, m_{m_i}, m_{m_i}; m_Z, m_l, m_{l_j} \right) \]
which gives
\[
|\mathcal{M}|^2 = |g_L \lambda_{\nu_3}^* \lambda_{km\ell} |^2 \epsilon_\mu(p_1 + p_2) \epsilon^* v(p_1 + p_2) \epsilon^* \epsilon_\mu(p_1 + p_2) \epsilon^* v(p_1 + p_2)
\]
(Eq. A4)
\[
\text{Using the completeness relations for the massive } Z \text{-boson, we have}
\]
\[
|\mathcal{M}|^2 = 2 \left( m_Z^2 - 4m_{m_i}^2 \right) |g_L \lambda_{\nu_3}^* \lambda_{km\ell} |^2 \frac{1}{M_Z^{2\mu}} \frac{(p_1 - p_2)^{\mu} (p_1 - p_2)^{\nu}}{M_Z} \left( p_1 + p_2 \right)^{\mu} (p_1 - p_2)^{\nu} \epsilon^* \epsilon_\mu(p_1 + p_2) \epsilon^* v(p_1 + p_2) v(p_1 + p_2)
\]
\[
|\mathcal{M}|^2 = 3.433 \times 10^{-5} \left| \lambda_{\nu_3}^* \lambda_{km\ell} \right|^2 \]
(C6)
Thus, the decay width is
\[
\Gamma(Z \rightarrow \ell \ell)_{\text{RPV}} = \frac{|\mathcal{M}|^2}{16\pi m_Z} \left( 1 - \frac{4m_{m_i}^2}{M_Z^2} \right) \simeq 7.48 \times 10^{-9} \times \left| \lambda_{\nu_3}^* \lambda_{km\ell} \right|^2 \text{ GeV}
\]
The total decay width of the Z boson is \( \Gamma_Z \simeq 2.495 \text{ GeV} \), so this gives us a branching ratio of
\[
B(Z \rightarrow \ell \ell)_{\text{RPV}} \simeq 3.0 \times 10^{-9} \times \left| \lambda_{\nu_3}^* \lambda_{km\ell} \right|^2 \]
(C8)
Comparing it to the experimental limits on the Z boson decay to differently flavoured leptons at 95% C.L., we have\([133]\)
\[
B(Z \rightarrow e\mu)_{\text{RPV}} < 7.5 \times 10^{-7} \quad \Rightarrow \quad \left| \lambda_{\nu_3}^* \lambda_{km\ell} \right| \lesssim 16.0
\]
\[
B(Z \rightarrow e\tau)_{\text{RPV}} < 9.8 \times 10^{-6} \quad \Rightarrow \quad \left| \lambda_{\nu_3}^* \lambda_{km\ell} \right| \lesssim 57.2
\]
\[
B(Z \rightarrow \mu\tau)_{\text{RPV}} < 1.2 \times 10^{-5} \quad \Rightarrow \quad \left| \lambda_{\nu_3}^* \lambda_{km\ell} \right| \lesssim 63.2
\]
(C9)
Owing to the assumption stated in Eqn. \([A2]\) the latter two branching ratios are zero automatically. Using the antisymmetry of the first two indices, the coupling on the last line can be expanded to
\[
\left| \lambda_{121} \lambda_{122}^* + \lambda_{131} \lambda_{132}^* + \lambda_{231} \lambda_{232}^* \right| < 8.0 \quad \text{(C9)}
\]
Using the bounds outlined in Table II of Ref.\([136]\), all the couplings mentioned here are about 0.5 – 0.8, assuming a right handed slepton mass of \( \sim 1 \text{ TeV} \). This clearly evades the bounds in Eqns. \([C9]\).

The other diagram in Fig. 6 for \( Z \rightarrow \ell_R \ell_R \) with neutrinos in the loop vanishes, since the value of the loop function depends on the mass of the fermion in the loop, as can be seen from Eqn. \([C1]\). The diagram for
$Z \to \ell_i L \ell_j L$ gives an equivalent contribution to the diagram calculated above, given as:

\[
\mathcal{B}(Z \to e\mu)_{\text{RPV}} < 7.5 \times 10^{-7} \quad \Rightarrow \quad |\lambda_{km2}^e\lambda_{km1}^\mu| \lesssim 19.6 \\
\mathcal{B}(Z \to e\tau)_{\text{RPV}} < 9.8 \times 10^{-6} \quad \Rightarrow \quad |\lambda_{km3}^e\lambda_{km1}^\tau| \lesssim 71 \\
\mathcal{B}(Z \to \mu\tau)_{\text{RPV}} < 1.2 \times 10^{-5} \quad \Rightarrow \quad |\lambda_{km3}^\mu\lambda_{km2}^\tau| \lesssim 78.6
\]

Note that both of the above limits are obtained assuming $Z$ boson decays to either left-handed leptons or right-handed leptons. If we assume both kind of leptons at once, the limits are weaker.

\[1\] Svjetlana Fajfer, Jernej F. Kamenik, and Ivan Nisandzic, “On the $B \to D^{(*)}\tau\nu$ Sensitivity to New Physics,” Phys. Rev. D 85, 094025 (2012). [arXiv:1203.2654 [hep-ph].]

\[2\] Marat Freytsis, Zoltan Ligeti, and Joshua T. Ruderman, “Flavor models for $B \to D^{(*)}\tau\nu$,” Phys. Rev. D 92, 054018 (2015). [arXiv:1506.08896 [hep-ph].]

\[3\] Debajyoti Choudhury, Anirban Kundu, Soumitra Nandi, and Sunando Kumar Patra, “Unified resolution of the $R(D)$ and $R(D^*)$ anomalies and the lepton flavor violating decay $h \to \mu\tau$,” Phys. Rev. D 95, 035021 (2017). [arXiv:1612.03617 [hep-ph].]

\[4\] Debajyoti Choudhury, Dilip Kumar Ghosh, and Anirban Kundu, “$B$ decay anomalies in an effective theory,” Phys. Rev. D 86, 114037 (2012). [arXiv:1210.5076 [hep-ph].]

\[5\] Debjyoti Bardhan, Pritibhajan Byakti, and Diptimoy Ghosh, “A closer look at the $R_D$ and $R_{D^*}$ anomalies,” JHEP 01, 125 (2017). [arXiv:1610.03938 [hep-ph].]

\[6\] Aleksandr Azatov, Debjyoti Bardhan, Diptimoy Ghosh, Francesco Sgarlata, and Elena Venturini, “Anatomy of $b \to c\tau\nu$ anomalies,” JHEP 11, 187 (2018). [arXiv:1805.03209 [hep-ph].]

\[7\] Quan-Yi Hu, Xin-Qiang Li, and Ya-Dong Yang, “$b \to c\tau\nu$ transitions in the standard model effective field theory,” Eur. Phys. J. C 79, 264 (2019). [arXiv:1810.04939 [hep-ph].]

\[8\] Pouya Asadi and David Shih, “Maximizing the Impact of New Physics in $b \to c\tau\nu$ Anomalies,” Phys. Rev. D 100, 115013 (2019). [arXiv:1905.03311 [hep-ph].]

\[9\] Rui-Xiang Shi, Li-Sheng Geng, Benjamin Grinstein, Sebastian Jäger, and Jorge Martin Camalich, “Revisiting the new-physics interpretation of the $b \to c\tau\nu$ data,” JHEP 12, 065 (2019). [arXiv:1905.08498 [hep-ph].]

\[10\] Danmir Bečirević, Marco Fedele, Ivan Nisandžić, and Andrey Tayduganov, “Lepton Flavor Universe tests through angular observables of $B \to D^{(*)}\tau\nu$ decay modes,” (2019). [arXiv:1907.02257 [hep-ph].]

\[11\] John D. Gómez, Néstor Quintero, and Eduardo Rojas, “Charged current $b \to c\tau\nu$ anomalies in a general $W$ boson scenario,” Phys. Rev. D 100, 093003 (2019). [arXiv:1907.08357 [hep-ph].]

\[12\] Pouya Asadi, Anna Hallin, Jorge Martin Camalich, David Shih, and Susanne Westhoff, “Complete framework for tau polarimetry in $B \to D^{(*)}\tau\nu$ decays,” Phys. Rev. D 102, 095028 (2020). [arXiv:2006.16416 [hep-ph].]

\[13\] Florian U. Bernlochner, Zoltán Ligeti, Michele Papucci, and Dean J. Robinson, “Combined analysis of semileptonic $B$ decays to $D$ and $D^*$: $R(D^{(*)})$, $|V_{cb}|$, and new physics,” Phys. Rev. D 95, 115008 (2017). [Erratum: Phys. Rev.D 97, 059902 (2018)]. [arXiv:1703.05330 [hep-ph].]

\[14\] Martin Jung and David M. Straub, “Constraining new physics in $b \to c\ell\nu$ transitions,” JHEP 01, 009 (2019). [arXiv:1801.01112 [hep-ph].]

\[15\] Debajyoti Choudhury, Anirban Kundu, Rusu Mandal, and Rahul Sinha, “Minimal unified resolution to $R_{K^{(*)}}$ and $R(D^{(*)})$ anomalies with lepton mixing,” Phys. Rev. Lett. 119, 151801 (2017). [arXiv:1706.08437 [hep-ph].]

\[16\] Amir Greljo, Dean J. Robinson, Bibhushan Shakya, and Jure Zupan, “$R(D^{(*)})$ from $W$ and right-handed neutrinos,” JHEP 09, 169 (2018). [arXiv:1804.04642 [hep-ph].]

\[17\] Ferruccio Feruglio, Paride Paradisi, and Oleyr Sumensari, “Implications of scalar and tensor explanations of $R_{K^{(*)}}$,” JHEP 11, 191 (2018). [arXiv:1806.10155 [hep-ph].]

\[18\] Quan-Yi Hu, Xin-Qiang Li, Yu Muramatsu, and Ya-Dong Yang, “$R$-parity violating solutions to the $R_{D^{(*)}}$ anomaly and their GUT-scale unifications,” Phys. Rev. D 99, 015008 (2019). [arXiv:1808.01419 [hep-ph].]

\[19\] Zhuo-Ran Huang, Ying Li, Cai-Dian Lu, M. Ali Paracha, and Chao Wang, “Footprints of New Physics in $b \to c\tau\nu$ Transitions,” Phys. Rev. D 98, 095018 (2018). [arXiv:1808.03565 [hep-ph].]

\[20\] Debjyoti Bardhan and Diptimoy Ghosh, “$B$ meson charged current anomalies: The post-Moriond 2019 status,” Phys. Rev. D 100, 011701 (2019). [arXiv:1904.10432 [hep-ph].]

\[21\] Diptimoy Ghosh, Marco Nardaccia, and S. A. Renner, “Hint of Lepton Flavour Non-Universality in $B$ Meson Decays,” JHEP 12, 131 (2014). [arXiv:1408.4097 [hep-ph].]

\[22\] Bhuvanjyoti Bhattacharya, Alakahba Datta, Jean-Pascal Guévin, David London, and Ryooutaro Watanabe, “Simultaneous Explanation of the $R_K$ and $R_{D^{(*)}}$ Puzzles: A Model Analysis,” JHEP 01, 015 (2017). [arXiv:1609.09078 [hep-ph].]

\[23\] Amir Greljo, Gino Isidori, and David Marzocca, “On the breaking of Lepton Flavor Universality in $B$ decays,” JHEP 07, 142 (2015). [arXiv:1506.01705 [hep-ph].]

\[24\] Debjyoti Bardhan, Pritibhajan Byakti, and Diptimoy Ghosh, “Role of Tensor operators in $R_K$ and $R_{K^*}$,” Phys. Lett. B 773, 505–512 (2017). [arXiv:1705.09305 [hep-ph].]

\[25\] Diptimoy Ghosh, “Explaining the $R_K$ and $R_{K^*}$ anomalies,” Eur. Phys. J. C 77, 694 (2017). [arXiv:1704.06240 [hep-ph].]

\[26\] Aritra Biswas, Soumitra Nandi, Ipsita Ray, and Sunando Kumar Patra, “New physics in $b \to s\ell\ell$ decays with complex Wilson coefficients,” Nucl. Phys. B 969, 115479 (2021). [arXiv:2004.14687 [hep-ph].]
Ashutosh Kumar Alok, Amol Dighe, Shireen Gangal, and Dinesh Kumar, “Continuing search for new physics in $b \rightarrow s \mu \mu$ decays: two operators at a time,” JHEP 06, 089 (2019) arXiv:1903.09617 [hep-ph].

Marco Ciuchini, Aníbal M. Coutinho, Marco Fedele, Enrico Franco, Ayan Paul, Luca Silvestrini, and Mauro Valli, “New Physics in $b \rightarrow s \ell^+ \ell^−$ confronts new data on Lepton Universality,” Eur. Phys. J. C 79, 719 (2019) arXiv:1903.09632 [hep-ph].

Alakabha Datta, Divya Sachdeva, and John Waite, “Unified explanation of $b \rightarrow s \mu^+ \mu^−$ anomalies, neutrino masses, and $B \rightarrow K^*$ puzzle,” Phys. Rev. D 100, 055015 (2019) arXiv:1905.04046 [hep-ph].

Srimoy Bhattacharya, Aritra Biswas, Zaineb Calcutawa, and Sumando Kumar Patra, “An in-depth analysis of $b \rightarrow c(s)$ semileptonic observables with possible $\mu - \tau$ mixing,” (2019) arXiv:1902.02796 [hep-ph].

Sokratis Trifinopoulos, “Revisiting R-parity violating interactions as an explanation of the B-physics anomalies,” Eur. Phys. J. C 78, 803 (2018) arXiv:1807.01638 [hep-ph].

Sokratis Trifinopoulos, “B-physics anomalies: The bridge between R-parity violating supersymmetry and colored dark matter,” Phys. Rev. D 100, 115022 (2019) arXiv:1904.12940 [hep-ph].

Wei Wang and Shuai Zhao, “Implications of the $R_K$ and $R_{K^*}$ anomalies,” Chin. Phys. C 42, 013105 (2018) arXiv:1704.08168 [hep-ph].

Giancarlo D’Ambrosio and Abhishek M. Iyer, “Flavour issues in warped custodial models: B anomalies and rare K decays,” Eur. Phys. J. C 78, 448 (2018) arXiv:1712.08122 [hep-ph].

Claudia Cornella, Ferruccio Feruglio, and Paride Paradisi, “Low-energy effects of Lepton Flavour Universality Violation,” JHEP 11, 012 (2018) arXiv:1803.00945 [hep-ph].

Wolfgang Altmannshofer, Peter Stangl, and David M. Straub, “Interpreting Hints for Lepton Flavor Universality Violation,” Phys. Rev. D 96, 055008 (2017) arXiv:1704.05435 [hep-ph].

Adam Falkowski, Marco Nardecchia, and Robert Ziegler, “Lepton Flavor Non-universality in B-meson Decays from a U(2) Flavor Model,” JHEP 11, 173 (2015) arXiv:1509.01249 [hep-ph].

Rodrigo Alonso, Benjamin Grinstein, and Jorge Martin Camalich, “Lepton universality violation and lepton flavor conservation in B-meson decays,” JHEP 10, 184 (2015) arXiv:1505.05164 [hep-ph].

Rusa Mandal, Rahul Sinha, and Diganta Das, “Testing New Physics Effects in $B \rightarrow K^* \ell^+ \ell^−$,” Phys. Rev. D 90, 096006 (2014) arXiv:1409.3088 [hep-ph].

J. Alda, J. Guasch, and S. Peñarrubia, “Anomalies in B mesons decays: A phenomenological approach,” (2020) arXiv:2012.14799 [hep-ph].

Shaukh Saad and Ánil Thapa, “Common origin of neutrino masses and $R_{D(s)}$, $R_{K(s)}$ anomalies,” Phys. Rev. D 102, 015014 (2020) arXiv:2004.07880 [hep-ph].
decays,” Journal of High Energy Physics 2021 (2021), 10.1007/JHEP03(2021)105.
[61] Roel Aaij et al. (LHCb), “Test of lepton universality using $B^{+}\rightarrow K^{+}\ell^{+}\ell^{-}$ decays,” Phys. Rev. Lett. 113, 151601 (2014) [arXiv:1406.6482 [hep-ex]].
[62] Roel Aaij et al. (LHCb), “Search for lepton-universality violation in $B^{+}\rightarrow K^{+}\ell^{+}\ell^{-}$ decays,” Phys. Rev. Lett. 122, 191801 (2019) [arXiv:1903.09252 [hep-ex]].
[63] Roel Aaij et al. (LHCb), “Test of lepton universality in beauty-quark decays,” (2021), [arXiv:2103.11769 [hep-ex]].
[64] Martin Bauer and Matthias Neubert, “Minimal Leptoquark Explanation for the $R_{D^{(*)}}$, $R_{K}$, and $(g-2)$ Anomalies,” Phys. Rev. Lett. 116, 141802 (2016) [arXiv:1511.01900 [hep-ph]].
[65] Innes Bigaran, John Gargalionis, and Raymond R. Volkas, “A near-minimal leptoquark model for reconciling flavour anomalies and generating radiative neutrino masses,” JHEP 10, 106 (2019) [arXiv:1906.01870 [hep-ph]].
[66] K. S. Babu, P. S. Bhupal Dev, Sudip Jana, and Anil Thapa, “Unified framework for $B$-anomalies, muon $g-2$ and neutrino masses,” JHEP 03, 179 (2021) [arXiv:2009.01771 [hep-ph]].
[67] Riccardo Barbieri, Gino Isidori, Andrea Pattori, and Fabrizio Senia, “Anomalies in $B$-decays and $U(2)$ flavour symmetry,” Eur. Phys. J. C76, 67 (2016) [arXiv:1512.01560 [hep-ph]].
[68] Suchismita Sahoo, Rukmani Mohanta, and Anjan K. Giri, “Explaining the $R_{K}$ and $R_{D^{(*)}}$ anomalies with vector leptoquarks,” Phys. Rev. D 95, 035027 (2017) [arXiv:1609.04367 [hep-ph]].
[69] Riccardo Barbieri, Christopher W. Murphy, and Fabrizio Senia, “B-Decay Anomalies in a Composite Leptoquark Model,” Eur. Phys. J. C77, 8 (2017) [arXiv:1611.04930 [hep-ph]].
[70] Carla Biggio, Marzia Bordone, Luca Di Luzio, and Giovanni Ridolfi, “Massive vectors and loop observables: the $g-2$ case,” JHEP 10, 002 (2016) [arXiv:1607.07621 [hep-ph]].
[71] Andreas Crivellin, Dario Müller, and Luc Schnell, “Combined constraints on first generation leptoquarks,” Phys. Rev. D 103, 115023 (2021) [arXiv:2104.06417 [hep-ph]].
[72] Andreas Crivellin, Christoph Greub, Dario Müller, and Francesco Saturnino, “Scalar Leptoquarks in Leptonic Processes,” JHEP 02, 182 (2021) [arXiv:2010.06593 [hep-ph]].
[73] Lorenzo Calibbi, Andreas Crivellin, and Tianjun Li, “Model of vector leptoquarks in view of the $B$-physics anomalies,” Phys. Rev. D 98, 115002 (2018) [arXiv:1709.00692 [hep-ph]].
[74] Ben Grégoire, Marco Nardecchia, and S. A. Renner, “Composite leptoquarks and anomalies in $B$-meson decays,” JHEP 05, 006 (2015) [arXiv:1412.1791 [hep-ph]].
[75] Diganta Das, Chandan Hati, Girish Kumar, and Namit Mahajan, “Towards a unified explanation of $R_{D^{(*)}}$, $R_{K}$ and $(g-2)$ anomalies in a left-right model with leptoquarks,” Phys. Rev. D 94, 055034 (2016) [arXiv:1605.06313 [hep-ph]].
[76] Ivo de Medeiros Varzielas and Stephen F. King, “$R_{K^{(*)}}$ with leptoquarks and the origin of Yukawa couplings,” JHEP 11, 100 (2018) [arXiv:1807.06023 [hep-ph]].
[77] Suchismita Sahoo and Rukmani Mohanta, “Impact of vector leptoquark on $\bar{B}\rightarrow K^{+}\ell^{+}\ell^{-}$ anomalies,” J. Phys. G 45, 085003 (2018) [arXiv:1806.01048 [hep-ph]].
[78] Damir Becirevic and Oleg Sumensari, “A leptoquark model to accommodate $R_{D^{(*)}}^{exp}<R_{K}$ and $R_{K^{(*)}}^{exp}<R_{K^{(*)}}^{SM}$,” JHEP 08, 104 (2017) [arXiv:1704.05835 [hep-ph]].
[79] Gudrun Hiller and Ivan Nisandzic, “$R_{K}$ and $R_{K^{(*)}}$ beyond the standard model,” Phys. Rev. D 96, 035003 (2017) [arXiv:1704.05444 [hep-ph]].
[80] Luca Di Luzio, Admir Grejlo, and Marco Nardecchia, “Gauge leptoquark as the origin of B-physics anomalies,” Phys. Rev. D 96, 115011 (2017) [arXiv:1708.08450 [hep-ph]].
[81] Lorenzo Calibbi, Andreas Crivellin, and Tosihiko Ota, “Effective Field Theory Approach to $b\rightarrow s\ell(\bar{c})$, $B\rightarrow K^{(*)}\tau\sigma$ and $B\rightarrow D^{(*)}\tau\nu$ with Third Generation Couplings,” Phys. Rev. Lett. 115, 181801 (2015) [arXiv:1506.02661 [hep-ph]].
[82] Andreas Crivellin, Dario Müller, and Tosihiko Ota, “Simultaneous explanation of $R_{D^{(*)}}^{D}$ and $b\rightarrow s\mu^{+}\mu^{-}$: the last scalar leptoquarks standing,” JHEP 09, 040 (2017) [arXiv:1703.09226 [hep-ph]].
[83] Lorenzo Calibbi, Andreas Crivellin, and Tianjun Li, “Model of vector leptoquarks in view of the b-physics anomalies,” Physical Review D 98 (2018), 10.1103/physrevd.98.115002.
[84] Monika Blanke and Andreas Crivellin, “$B$ Meson Anomalies in a Pati-Salam Model within the Randall-Sundrum Background,” Phys. Rev. Lett. 121, 011801 (2018) [arXiv:1801.07256 [hep-ph]].
[85] Alexandre Carvunis, Andreas Crivellin, Diego Guadagnoli, and Shireen Gangel, “The Forward-Backward Asymmetry in $B\rightarrow D^{(*)}\tau\nu$: One more hint for Scalar Leptoquarks?” (2021) [arXiv:2106.09610 [hep-ph]].
[86] Shaikh Saad, “Combined explanations of $(g-2)_{\mu}$, $R_{D^{(*)}}$, $R_{K^{(*)}}$ anomalies in a two-loop radiative neutrino mass model,” Phys. Rev. D 102, 015019 (2020) [arXiv:2005.04332 [hep-ph]].
[87] Rhorry Gauld, Florian Götzert, and Ulrich Haisch, “An explicit Z-boson explanation of the $B\rightarrow K^{(*)}\mu^{+}\mu^{-}$ anomaly,” JHEP 01, 069 (2014) [arXiv:1310.1082 [hep-ph]].
[88] Andreaz J. Buras, Fulvia De Fazio, and Jennifer Girrbach, “331 models facing new $b\rightarrow s\mu^{+}\mu^{-}$ data,” JHEP 02, 112 (2014) [arXiv:1311.6729 [hep-ph]].
[89] Wolfgang Altmannshofer, Stefania Gori, Maxim Pospelov, and Itay Yavin, “Quark flavor transitions in $L_{u}-L_{s}$ models,” Phys. Rev. D 89, 095033 (2014) [arXiv:1403.1269 [hep-ph]].
[90] Andreaz J. Buras, Fulvia De Fazio, and Jennifer Girrbach, “331 models facing new $b\rightarrow s\mu^{+}\mu^{-}$ data,” JHEP 02, 112 (2014) [arXiv:1311.6729 [hep-ph]].
[91] Wolfgang Altmannshofer, Stefania Gori, Maxim Pospelov, and Itay Yavin, “Quark flavor transitions in $L_{u}-L_{s}$ models,” Phys. Rev. D 89, 095033 (2014) [arXiv:1403.1269 [hep-ph]].
[92] Andreaz J. Buras, Fulvia De Fazio, and Jennifer Girrbach, “331 models facing new $b\rightarrow s\mu^{+}\mu^{-}$ data,” JHEP 02, 112 (2014) [arXiv:1311.6729 [hep-ph]].
[93] Sohiane M. Boucenna, Alejandro Celis, Javier Fuentes-Martin, Avelino Vicente, and Javier Virto, “Phe-
nomenclature of an $SU(2) \times SU(2) \times U(1)$ model with lepton-flavour non-universality,” JHEP 12, 059 (2016), arXiv:1608.01349 [hep-ph].

[94] Alakabha Datta, Qiaojie Liao, and Danny Marfatia, “A light $Z'$ for the R-breaking and nonstandard neutrino interactions,” Phys. Lett. B 768, 265–269 (2017), arXiv:1702.01099 [hep-ph].

[95] Andreas Crivellin, Lars Hofer, Joaquim Matias, Ulrich Nierste, Stefan Pokorski, and Janusz Rosiek, “Lepton-flavour violating $B$ decays in generic $Z'$ models,” Phys. Rev. D 92, 054013 (2015), arXiv:1504.07928 [hep-ph].

[96] Rodrigo Alonso, Peter Cox, Chengcheng Han, and Tsutomu T. Yanagida, “Flavoured $B \rightarrow L$ local symmetry and anomalous rare $B$ decays,” Phys. Lett. B 774, 643–648 (2017), arXiv:1705.03858 [hep-ph].

[97] Rodrigo Alonso, Peter Cox, Chengcheng Han, and Tsutomu T. Yanagida, “Anomaly-free local horizontal symmetry and anomaly-full rare $B$-decays,” Phys. Rev. D 96, 071701 (2017), arXiv:1704.08158 [hep-ph].

[98] Guang Hua Duan, Xiang Fan, Marianna Frank, Chengcheng Han, and Jin Min Yang, “A minimal $U(1)'$ extension of MSSM in light of the $B$ decay anomaly,” Phys. Lett. B 789, 54–58 (2019), arXiv:1808.04116 [hep-ph].

[99] T. Hurth, F. Mahmoudi, D. Martinez Santos, and Guang Hua Duan, Xiang Fan, Mariana Frank, Rodrigo Alonso, Peter Cox, Chengcheng Han, and Jin Min Yang, “A minimal $U(1)'$ model with anomaly: A possible hint for natural $R$-parity violation,” Phys. Rev. D 102, 015031 (2020), arXiv:2002.12910 [hep-ph].

[100] P. S. Bhupal Dev, Amarjit Soni, and Fang Xu, “Hints of Natural Supersymmetry in Flavor Anomalies?” (2021), arXiv:2106.15647 [hep-ph].

[101] Chuan-Hung Chen, Takaaki Nomura, and Hiroshi Okada, “Excesses of muon $g - 2$, $R_{\mu}^{(\text{SR})}$, and $R_K$ in a leptoquark model,” Phys. Lett. B 774, 456–464 (2017), arXiv:1703.03251 [hep-ph].

[102] Min-Di Zheng and Hong-Hao Zhang, “Studying the $b\to s\ell^+\ell^-$ anomalies and $(g-2)_\mu$ in $R$-parity violating MSSM framework with the inverse seesaw mechanism,” Phys. Rev. D 104, 115023 (2021), arXiv:2105.06954 [hep-ph].

[103] Gautam Bhattacharyya and Palash B. Pal, “New constraints on R-parity violation from proton stability,” Phys. Lett. B 439, 81–84 (1998), arXiv:hep-ph/9806214.

[104] Vernon D. Barger, G. F. Giudice, and Tao Han, “Some New Aspects of Supersymmetry R-Parity Violating Interactions,” Phys. Rev. D 49, 2987 (1994).

[105] Rohini M. Godbole, Probir Roy, and Xerxes Tata, “Tau signals of R-parity breaking at LEP-200,” Nucl. Phys. B 401, 67–92 (1993), arXiv:hep-ph/9209251.

[106] Gautam Bhattacharyya, “R-parity violating supersymmetric Yukawa couplings: A Minireview,” Nucl. Phys. B Proc. Suppl. 52, 83–88 (1997), arXiv:hep-ph/9608415.

[107] R. M. Godbole, S. Pakvasa, S. D. Rindani, and X. Tata, “Fermion dipole moments in supersymmetric models with explicitly broken R-parity,” Phys. Rev. D 61, 113003 (2000), arXiv:hep-ph/9912415.

[108] Gautam Bhattacharyya, “A Brief review of R-parity violating couplings,” in Workshop on Physics Beyond the Standard Model: Beyond the Accelerator and Nonaccelerator Approaches (1997) arXiv:hep-ph/9709395.

[109] R. Barbier et al., “R-parity violating supersymmetry,” Phys. Rept. 420, 1–202 (2005), arXiv:hep-ph/0406039.

[110] Wolfgang Altmannshofer, Patricia Ball, Aoife Bharucha, Andréj J. Buras, David M. Straub, and Michael Wick, “Symmetries and Asymmetries of $B \to K^\pm \mu^\pm \nu^\mp$ Decays in the Standard Model and Beyond,” JHEP 01, 019 (2009), arXiv:0811.1214 [hep-ph].

[111] Alexandre Carvunis, Francesco Dettori, Shireen Gangal, Diego Guadagnoli, and Camille Normand, “On the effective lifetime of $B_s \to \mu^+\mu^-$,” (2021), arXiv:2102.13390 [hep-ex].

[112] Yasmine Sara Amhis et al. (HFLAV), “Averages of $b$-hadron, $c$-hadron, and $\tau$-lepton properties as of 2018,” Eur. Phys. J. C 81, 226 (2021), arXiv:1909.12524 [hep-ex].

[113] M. Misiak et al., “Updated NNLO QCD predictions for the weak radiative $B$-meson decays,” Phys. Rev. Lett. 114, 221801 (2015), arXiv:1503.01789 [hep-ph].

[114] Ayan Paul and David M. Straub, “Constraints on new physics from radiative $B$ decays,” JHEP 04, 027 (2017), arXiv:1608.02556 [hep-ph].

[115] Georges Aad et al. (ATLAS), “Search for supersymmetry in events with four or more charged leptons in $139 fb^{-1}$ of $\sqrt{s} = 13$ TeV $pp$ collisions with the ATLAS detector,” (2021), arXiv:2103.11684 [hep-ex].

[116] Cristiano Alpigiani et al., “Universality Triangle Analysis in the Standard Model and Beyond. (check updates at http://utfit.org/UTfit/ResultsSummer2018NP),” in
[126] Subhendu Rakshit, Gautam Bhattacharyya, and Amitava Raychaudhuri, “R-parity violating trilinear couplings and recent neutrino data,” Phys. Rev. D 59, 091701 (1999), arXiv:hep-ph/9811500.

[127] T. Aaltonen et al. (CDF), “Search for R-parity Violating Decays of τ Sneutrinos to eμ, μτ, and eτ Pairs in pp Collisions at √s = 1.96 TeV,” Phys. Rev. Lett. 105, 191801 (2010), arXiv:1004.3042 [hep-ex].

[128] Khachatryan, V. and Sirunyan, A. M. and Tumasyan, A. and Adam, W. and Asilar, E. and Bergauer, T. and Brandstetter, J. and Brondolin, E. and Dragicevic, M. and Erö, J. and et al., “Search for lepton flavour violating decays of heavy resonances and quantum black holes to an eμ pair in proton–proton collisions at √s = 8 TeV,” The European Physical Journal C 76 (2016), 10.1140/epjc/s10052-016-4149-y.

[129] Morad Aaboud et al. (ATLAS), “Search for new phenomena in different-flavour high-mass dilepton final states in pp collisions at √s = 13 TeV with the ATLAS detector,” Eur. Phys. J. C 76, 541 (2016), arXiv:1607.08079 [hep-ex].

[130] Morad Aaboud et al. (ATLAS), “Search for lepton-flavor violation in different-flavor, high-mass final states in pp collisions at √s = 13 TeV with the ATLAS detector,” Phys. Rev. D 98, 092008 (2018) [arXiv:1807.06573 [hep-ex]].

[131] Morad Aaboud et al. (ATLAS), “Search for supersymmetry in events with four or more leptons in √s = 13 TeV pp collisions with ATLAS,” Phys. Rev. D 98, 032009 (2018), arXiv:1804.03602 [hep-ex].

[132] Georges Aad et al. (ATLAS), “Search for supersymmetry in events with four or more leptons in √s = 8 TeV pp collisions with the ATLAS detector,” Phys. Rev. D 90, 052001 (2014), arXiv:1405.5086 [hep-ex].

[133] P. A. Zyla et al. (Particle Data Group), “Review of Particle Physics,” PTEP 2020, 083C01 (2020).

[134] A. M. Baldini et al. (MEG), “Search for the lepton flavour violating decay μ^+ → e^+ γ with the full dataset of the MEG experiment,” Eur. Phys. J. C 76, 434 (2016), arXiv:1605.05081 [hep-ex].

[135] Hiren H. Patel, “Package-X: A Mathematica package for the analytic calculation of one-loop integrals,” Comput. Phys. Commun. 197, 276–290 (2015), arXiv:1503.01469 [hep-ph].

[136] Yee Kao and Tatsu Takeuchi, “Single-Coupling Bounds on R-parity violating Supersymmetry, an update,” (2009), arXiv:0910.4980 [hep-ph].