Exotic Leptonic solutions to observed anomalies in lepton universality observables and more.

23rd DAE-BRNS High Energy Physics Symposium 2018,
IIT Chennai, 10-14 Dec. 2018.

By : Lobsang Dhargyal.
Harish-Chandra Research Institute, HBNI, Jhusi, Allahabad.

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Particles	$SU(3)_c$	$SU(2)_L$	$U(1)_Y$	$U(1)_F$	Z_2
ϕ_Q	3	2	7/6	0	-1
ϕ_l	1	2	1/2	0	-1
F_{iL}	1	1	Y_i	n_i	-1
F_{iR}	1	1	Y_i	0	-1
N_{jR}	1	1	0	0	-1
S	1	1	0	0	-1
ϕ	1	1	0	$n_\phi = n_\mu = -n_e$	+1

Table: The charge assignments of new particles under the full gauge group $SU(3)_c \times SU(2)_L \times U(1)_Y \times U(1)_F$. Where $i = e, \mu, \tau$ and $j = 1, 2, 3$.

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- $C_9^{NP} = -C_{10}^{NP} = N\frac{Y_b Y_s^* |Y_\mu|^2}{2\times 32\pi\alpha_{EM} m^2_{m_{F_\mu}}}[F(x_Q, x_{H_I^0}) + F(x_Q, x_{A_I})]$

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- where $F(x,y) = \frac{1}{(1-x)(1-y)} + \frac{x^2 \ln[x]}{(1-x)^2(x-y)} + \frac{y^2 \ln[y]}{(1-y)^2(y-x)}$ with $x_Q = \frac{m^2_{\phi_Q}}{m^2_{F_\mu}}$, $x_{H_I^0} = \frac{m^2_{H_I^0}}{m^2_{F_\mu}}$, $x_{A_I} = \frac{m^2_{A_I}}{m^2_{F_\mu}}$ and $N^{-1} = \frac{4G_F}{\sqrt{2}} V_{tb} V_{ts}^*$.

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- one of the peculiarity of our model is that simplest way to make theory free of axial anomaly is to set $Y_\mu = -Y_e$ and $n_{mu} = -n_e$ which forbid F_e to have Yukawa coupling with any SM fermions and hence it predict a stable heavy charged lepton.

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- Now if we have $\mathcal{L}_{NP} = \sum_{i=1}^{3} h_i \bar{Q}_{i\,L} L_{4R} \phi_{LQ} + \sum_{j=1}^{3} h_j \bar{L}_{j\,L} L_{4R} S + m_F \bar{L}_{4L} L_{4R} + h.c.$.

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- One key new convention that we have adopted here is $\pi \leq \theta_{12} \leq \frac{3\pi}{2}$ and $\frac{3\pi}{2} \leq \theta_{13}, \theta_{23} \leq 2\pi$ in which the first and second raw of CKM matrix have opposite sign relative the third raw compared to the usual convention.

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- due to very very stringent constrains from $K^0 - \bar{K}^0$ and $B^0 - \bar{B}^0$ oscillations, we impose $h'_d = -h_d V_{ud} - h_s V_{cd} + h_b V_{td} = 0$.

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- One key new convention that we have adopted here is $\pi \leq \theta_{12} \leq \frac{3\pi}{2}$ and $\frac{3\pi}{2} \leq \theta_{13}, \theta_{23} \leq 2\pi$ in which the first and second raw of CKM matrix have opposite sign relative the third raw compared to the usual convention.
- due to very very stringent constrains from $K^0 - \bar{K}^0$ and $B^0 - \bar{B}^0$ oscillations, we impose $h'_d = -h_d V_{ud} - h_s V_{cd} + h_b V_{td} = 0$. This require h_d to be complex if we take h_b and h_b to be real such that $h_s = \frac{h_b}{a}$.

New leptonic solutions to $R(D^{(*)})$.

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- In very recently we have proposed a little different model in which at low mass regime, the model can explain the $R(K^{(*)})$, muon (g-2) as well as smallness of neutrino masses, while in the high mass regime the model can explain the primodal Lithium problem and also it can have new composite DM candidates.

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- Besides the above mentioned flavor imprints, these models have very peculiar collider signatures such as prediction of existence of a stable charged lepton etc.
- Our recent work in [4] can explain the $R(K^{(*)})$, muon (g-2) as well as smallness of neutrino masses, the primodal Lithium problem and also new composite DM.

THANK YOU!

Talk is based on following publications. (2017-2018).

1. Phenomenology of $U(1)_F$ extension of inert-doublet model with exotic scalars and leptons. Lobsang Dhargyal. [Eur. Phys. J. C (2018) 78:150.]
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3. Implications of a vector like lepton doublet and scalar Leptoquark on $R(D^{(*)})$. Lobsang Dhargyal and Santosh Kumar Rai. [arXiv:1806.01178]
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