# Erratum: Baryon and lepton number as local gauge symmetries [Phys. Rev. D 82, 011901 (2010)]

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Section III.B of our paper contained a number of errors. It should be replaced with the following version.

### B. Leptonic sector

The interactions that generate masses for the new charged leptons in case 1) are:

$$-\Delta\mathcal{L}_l^{(1)} = Y_E' \bar{l}_L' H e_R' + \text{h.c.} \tag{1}$$

while for the neutrinos they are

$$-\Delta\mathcal{L}_\nu^{(1)} = Y_\nu l H \nu^C + Y_\nu' l' H N + \frac{\lambda_a}{2}\nu^C S_L \nu^C + \lambda_b \nu^C S_L^\dagger N + \text{h.c.}, \tag{2}$$

where $S_L \sim (1, 1, 0, 0, 2)$ is the Higgs that breaks $U(1)_L$, generating masses for the right-handed neutrinos and the quark-phobic $Z_L'$. We introduce the notations $\nu^C = (\nu_R)^C$ and $N = (\nu_R')^C$. After symmetry breaking the mass matrix for neutrinos in the left-handed basis, $(\nu, \nu', N, \nu^C)$, is given by the eight by eight matrix

$$\mathcal{M}_N = \begin{pmatrix} 0 & 0 & 0 & M_D \\ 0 & 0 & M_D' & 0 \\ 0 & (M_D')^T & 0 & M_b \\ M_D^T & 0 & M_b^T & M_a \end{pmatrix}. \tag{3}$$

Here, $M_D = Y_\nu v_H/\sqrt{2}$ and $M_a = \lambda_a v_L/\sqrt{2}$ are $3\times 3$ matrices, $M_b = \lambda_b v_L^*/\sqrt{2}$ is a $1\times 3$ matrix, $M_D' = Y_\nu' v_H/\sqrt{2}$ is a number and $\langle S_L\rangle = v_L/\sqrt{2}$. Let us assume that the three right-handed neutrinos $\nu^C$ are the heaviest. Then, integrating them out generates the following mass matrix for the three light-neutrinos:

$$\mathcal{M}_\nu = M_D M_a^{-1} M_D^T. \tag{4}$$

In addition, a Majorana mass $M'$ for the fourth generation right-handed neutrino $N$,

$$M' = M_b M_a^{-1} M_b^T, \tag{5}$$

is generated. Furthermore, suppose that $M' \ll M_D'$, then the new fourth generation neutrinos $\nu'$ and $N$ are quasi-Dirac with a mass equal to $M_D'$. Of course we need this mass to be greater than $M_Z/2$ to be consistent with the measured $Z$-boson width. In this model, we have a consistent mechanism for neutrino masses which is a particular combination of Type I seesaw.

The interactions that generate masses for the new leptons in case 2) are:

$$-\Delta\mathcal{L}_l^{(2)} = Y_E'' \bar{l}_R' H e_L' + \text{h.c.} \tag{6}$$

$$-\Delta\mathcal{L}_\nu^{(2)} = Y_\nu l H \nu^C + Y_\nu'' \bar{l}_R' \tilde{H} \nu_L' + \frac{\lambda_a}{2}\nu^C S_L \nu^C + \lambda_c \nu^C S_L^\dagger \nu_L' + \lambda_l \bar{l}_R' l_L S_L + \lambda_e \bar{e}_R e_L' S_L^\dagger + \text{h.c.} \tag{7}$$

Notice that in this case, $S_L$ does not get a vacuum expectation value (VEV) in order to avoid tree level lepton flavor violation. Then, the neutrinos can be Dirac fermions and one has to introduce a new scalar field to break $U(1)_L$. Let us say $S_L' \sim (1, 1, 0, 0, n_L)$, where $n_L \neq \pm 2, \pm 6$. Notice that if in this case we do not introduce $S_L$, the heavy extra Dirac neutrino is stable and it is difficult to satisfy the experimental bounds from dark matter direct detection in combination with the collider bounds on a heavy stable Dirac neutrino.

In order to complete the discussion of symmetry breaking we introduce a new Higgs, $S_B$, with nonzero baryon number (but no other gauge quantum numbers) which gets the VEV, $v_B$, breaking $U(1)_B$ and giving mass to the leptophobic $Z_B'$. In summary, the Higgs sector in case 2) is composed of the standard model (SM) Higgs, $S_L$, $S_L'$, $S_B$ and $X$. This is the minimal Higgs sector needed to have a realistic renormalizable theory where $B$ and $L$ are both gauged, and have a dark matter (DM) candidate. Notice that in case 1), one could have a viable DM candidate if one introduces the interaction c$(H^\dagger\phi)^2 S_B$ + h.c..

 