Comment on ''Majoron emitting neutrinoless double beta decay in the electroweak chiral gauge extensions''

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We point out that if the Majoron-like scheme is implemented within a 3-3-1 model, there must exist at least three different mass scales for the scalar vacuum expectation values in the model. [S0556-2821(99)00721-3]

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In a recent paper by Pisano and Sharma [1] the Majoron scheme was implemented in a 3-3-1 model [2]. In that paper two different scales of vacuum expectation values (VEV's) in the scalar sector have been considered: one related with electroweak symmetry breaking and the other with SU(3) breaking. Here we show that the model is consistent with the experimental value of the ρ parameter only if three mass scales are introduced.

It is a well-known fact that Higgs triplets under the standard $SU(2)_L \otimes U(1)_Y$ gauge group have to have vacuum expectation values which are smaller than the electroweak scale in order not to spoil the agreement between the theoretical and the experimental value of the electroweak ρ parameter ($\rho = M_Z / M_W c_W$) [3–5]. This is due to the fact that triplets and doublets give different contributions to the $W^\pm$ and Z-boson masses. This result does not depend on the hypercharge of the Higgs triplet. For instance, a Higgs doublet and a Higgs triplet with $Y=2$ with spontaneous (Majoron model [3]) or explicit (non-Majoron model [4,5]) lepton number violation give

$$M_W^2 = \frac{g^2}{4}(v_D^2 + 2v_T^2), \quad M_Z^2 = \frac{g^2}{4c_W^2}(v_D^2 + 4v_T^2), \tag{1}$$

where v_D and v_T denote the VEV's of the doublet and the triplet, respectively. Notice that the condition $v_D = v_T$ violates the $\rho = 1$ condition. We cannot even use $v_D^2 + 2v_T^2 = (246\ \text{GeV})^2$. The only way to avoid this problem is that $v_T \leqslant 5.5$ GeV (if $v_D = 246$ GeV) using the present experimental value for the ρ parameter (see below). Thus, we see that these sort of models have two different mass scales: v_T and v_D.

Next, let us consider a similar situation in the context of the 3-3-1 model [2]. In that model in order to give mass to all the fermions it is necessary to introduce three Higgs triplets and a Higgs sextet. Two of the triplets and the sextet have the neutral component in a doublet of the subgroup SU(2); we denote the respective VEV's by v_η, v_ρ, and v_{DS}. The other triplet has its neutral component transforming as a singlet under SU(2) and the sextet has another neutral field transforming as a triplet under SU(2). Let us denote their respective VEV's by v_χ [the VEV which is in control of the SU(3) breaking] and v_{TS}. The $W^\pm$ and Z-boson masses, neglecting terms of the order $v_i v_j / v_\chi^2$ $(i,j = \eta, \rho, DS, DT)$, are given by

$$M_W^2 \approx \frac{g^2}{4}(v_\eta^2 + v_\rho^2 + 2v_{DS}^2 + 4v_{TS}^2), \tag{2}$$

and

$$M_Z^2 \approx \frac{g^2}{4c_W^2}(v_\eta^2 + v_\rho^2 + 2v_{DS}^2 + 8v_{TS}^2), \tag{3}$$

respectively.

We see from Eqs. (2) and (3) that as in the case of the $SU(2)_L \otimes U(1)_Y$ model given in Eq. (1), the triplet v_{TS} contributes in a different way to the $W^\pm$ and Z-boson masses. We can estimate the order of magnitude of v_{TS} by assuming that $v_\eta \approx v_\rho \approx v_{DS} \equiv \tilde{v}$ and using the experimental value of the ρ parameter: $\rho = 0.9998 \pm 0.0008$ [6]. From Eqs. (2) and (3) we have

$$\rho = \frac{1+r}{1+2r}, \quad \sqrt{r} = \frac{v_{TS}}{\tilde{v}}, \tag{4}$$

which implies the upper limit for $r \leqslant 0.001$ or $v_{TS} \leqslant 3.89$ GeV for $\tilde{v}^2 = (246/2)^2$ GeV^2. If we make $v_{TS} = v_\eta = v_\rho = v_{DS}$, as it has been done in Ref. [1], we violate the $\rho = 1$ condition (it gives $\rho = 2/3$). In conclusion, the model must have at least three different mass scales in the scalar vacuum expectation values: v_{TS}, $\tilde{v}$, and v_χ.

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[1] F. Pisano and S. Shelly Sharma, Phys. Rev. D **57**, 5670 (1998).
[2] F. Pisano and V. Pleitez, Phys. Rev. D **46**, 410 (1992); P. M. Frampton, Phys. Rev. Lett. **69**, 2889 (1992).
[3] G. B. Gelmini and M. Roncadelli, Phys. Lett. **99B**, 411 (1981).
[4] J. Schechter and J. W. F. Valle, Phys. Rev. D **22**, 2227 (1980).
[5] T. P. Cheng and L-F. Li, Phys. Rev. D **22**, 2860 (1982).
[6] Particle Datta Group, C. Caso *et al.*, Eur. Phys. J. C **3**, 1 (1998).

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