Comment on "Number of Neutrinos in the Standard Model and Its Extensions to Supersymmetry"

Recently, Deshpande *et al.*[1] pointed out that the results of the W- and the Z-boson production at CERN give interesting bounds on the number of light neutrinos.[2] They considered

$$R \equiv \frac{\sigma(W^+ + W^-)B(W \to e\nu)}{\sigma(Z)B(Z \to e^+e^-)},$$

where the B's are the branching ratios. Using the experimental value of R and the QCD calculated value for $\sigma(W^+ + W^-)/\sigma(Z)$, they showed that the data are consistent with at most three light neutrinos in the standard model.

In their analysis the authors assumed that all the charged leptons (quarks) belonging to the additional generations have masses greater than M_W $(M_Z/2)$ and thus do not contribute to the W and the Z widths. The current result on the top-quark mass of between 30 and 50 GeV makes the assumption about the additional quark masses very reasonable. However, the experimental bound on the mass of the charged lepton, L, is only 22 GeV; so there may be one or more charged leptons lurking around between 22 GeV and M_W. We have done a similar analysis allowing the charged leptons in the additional generations to have masses less than M_W. Our results for the ratio $R' \equiv B(W \to e\nu)/B(Z \to e^+e^-)$ versus the charged-lepton mass are shown in Fig. 1 for various choices of the number of neutrinos and "light" charged leptons $(m_L < M_W)$, and for three different top-quark masses. masses. The upper bound on R used in Ref. 1, $R \lesssim 0.65$, and the lower bound $\sigma(W^+ + W^-)/\sigma(Z) \geqslant 3.1$, also as given in Ref. 1, correspond to $R' \lesssim 2.79$. Figure 1 then shows that additional generations are still allowed. The additional charged leptons must have masses less than about 50 GeV, and could be seen at TRISTAN, Stanford Linear Collider, and LEP. For the case $m_L > M_W$ the ratio R' is very sensitive to N_ν, thus giving the stronger bound.[1] For the case $m_L < M_W$, the additional leptons contribute almost equally to Γ_W and Γ_Z, thus making the ratio R' much less sensitive to N_ν. Figure 1 also shows that the number of neutrinos allowed is quite sensitive to the top-quark mass. The values for R and $\sigma(W^+ + W^-)/\sigma(Z)$ above imply that m_t cannot be larger than 50 GeV and be consistent with the three known generations.[3] N_ν is also extremely sensitive to the value for $\sigma(W^+ + W^-)/\sigma(Z)$; a 10% decrease in this ratio would allow many light neutrinos.

In Fig. 1 we also present our results for the broken supersymmetric SU(2) ⊗ U(1) model with three generations. We take the masses of the scalar leptons to be less than M_W, the masses of the W-inos (Z-inos) to be close to or greater than M_W $(M_Z/2)$, and the mass of the scalar quarks to be greater than $M_Z/2$. This is motivated in part by the monojets observed at CERN. From Fig. 1 we see that the upper bound of 2.79 for R' would be allowed provided the scalar lepton masses are less than about 35 GeV.

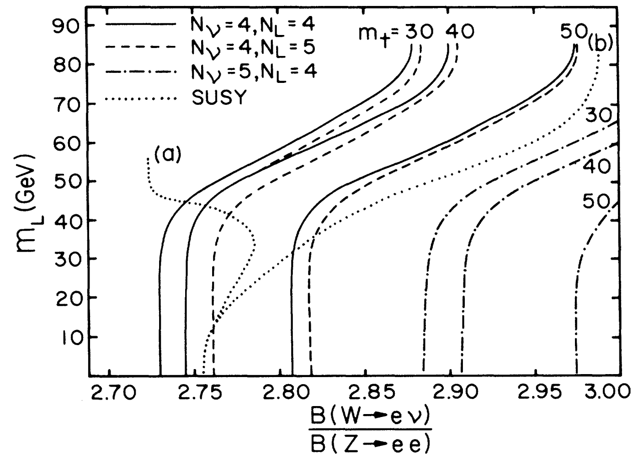

FIG. 1. The branching ratios $B(W \to e\nu)/B(Z \to e^+e^-)$ including extra leptons vs the mass of the extra charged lepton m_L. The mass of the extra neutrino is taken to be zero. N_ν is the total number of neutrinos; N_L is the total number of charged leptons. m_t is the mass of the top quark in gigaelectronvolts. For the case $N_L = 5$ one extra charged lepton has a mass fixed at 22 GeV, the other's mass is m_L. For the supersymmetric case the mass of the charged scalar lepton is m_L with the mass of the scalar neutrino taken equal to (curve *a*) m_L or (curve *b*) zero. m_t is fixed at 40 GeV for the supersymmetric case.

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Received 21 May 1985
PACS numbers: 14.60.Gh, 11.30.Pb, 12.10.Ck, 14.80.Er

[1]N. G. Deshpande, G. Eilam, V. Barger, and F. Halzen, Phys. Rev. Lett. **54**, 1757 (1985).

[2]F. Halzen and K. Mursula, Phys. Rev. Lett. **51**, 857 (1983); K. Hikasa, Phys. Rev. D **29**, 1939 (1984).

[3]The R' values for the three known families are 2.709, 2.725, and 2.790 for a top mass of 30, 40, and 50 GeV.