STERILE NEUTRINOS IN THE GRAND UNIFIED GROUP E_6

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Recent short-baseline neutrino oscillation experiments have led us to ask whether an adequate description of neutrino masses and mixings can be obtained using just three neutrinos which are doublets of $SU(2)_L$ [left-handed electroweak SU(2)] [1]. One or more light "sterile" [$SU(2)_L$-singlet] neutrinos may be required in addition. This short note is to remind readers of the opportunity for three light sterile neutrinos within the grand unified group [2] E_6. Some details may be found in Ref. [3].

Ths standard model group $SU(3)_{\rm color} \times SU(2)_{\rm L} \times U(1)$ can be incorporated into a grand unified group. Popular candidates include $SU(5) \subset SO(10) \subset E_6$. Each quark and lepton family constitute a $5^* + 10$ of SU(5) (without right-handed neutrinos). Adding a right-handed neutrino N [an SU(5) singlet] to each such hypermultiplet, one gets a 16 of SO(10). A right-handed neutrino can pair with a left-handed one to generate a Dirac mass m_D as occurs for charged leptons and quarks. However, the neutrality of the right-handed neutrino under the standard model group allows it to have a large Majorana mass M, leading via the seesaw mechanism to light-neutrino masses $m = m_D^2/M$. At this stage there are three light neutrinos (mostly electroweak doublets) and three heavy ones (mostly electroweak singlets).

Proceeding beyond SO(10), a 10-plet of that group [a $5 + 5^*$ of SU(5)] can be added to each quark and lepton family. It consists of quarks which are singlets under $SU(2)_L$ and $SU(2)_R$, and leptons which are doublets under both. To form the smallest E_6 representation, a 27-plet, all one need add is another singlet n of SO(10). The n is a sterile neutrino with neither L nor R isospin. As there is nothing left for it to pair up with, it is naturally light and of Majorana nature. It would have to mix, however, with standard model light neutrinos in order to account for some of the reported anomalies in short-baseline neutrino experiments.

If grand unified groups are the source of sterile neutrinos (either N or n) then they come in threes. While present data do not show a significant advantage in enlarging the number of sterile neutrinos to three, this possibility should be kept in mind when searching for motivations for such neutrinos.

References

[1] See, for example, S. J. Brice, S. Geer, D. Harris, B. Kayser, S. Parke, C. Polly, R. Tschirhart, G. Zeller *et al.*, "Short-Baseline Neutrino Focus Group Report," Fermilab report No. FERMILAB-FN-0947; J. M. Conrad, C. M. Ignarra, G. Karagiorgi, M. H. Shaevitz and J. Spitz, "Sterile Neutrino Fits to Short Baseline Neutrino Oscillation Measurements," arXiv:1207.4765 [hep-ex].

[2] F. Gürsey, P. Ramond, and P. Sikivie, Phys. Lett. **B60**, 177 (1976).

[3] J. L. Rosner, "E_6 and Exotic Fermions," Comments on Nucl. and Particle Phys. **15**, 195 (1986).