THE ELECTRON NEUTRINO MASS

These limits apply to ν_1, the primary mass eigenstate in ν_e. They would also apply to any other ν_j which mixes strongly in ν_e and has sufficiently small mass that it can occur in the respective decay. The neutrino mass may be of a Dirac or Majorana type; the former conserves total lepton number while the latter violates it. Either would violate lepton family number, since nothing forces the neutrino mass eigenstates to coincide with the neutrino interaction eigenstates. For limits on a Majorana ν_e mass, see the section on "Searches for Massive Neutrinos and Lepton Mixing," part (C), entitled "Searches for Neutrinoless Double-β Decay."

The square of the neutrino mass $m^2_{\nu_e}$ is measured in tritium beta decay experiments by fitting the shape of the beta spectrum near the endpoint; results are given in one of the tables in this section. In many experiments, it has been found to be significantly negative. In the 1994 edition of this *Review*, it was noted that the combined probability of a positive result was 3.5%. The problem has been exacerbated by the precise and careful experiments reported in two new papers (BELESEV 95 and STOEFFL 95). Both groups conclude that unknown effects cause the accumulation of events in the electron spectrum near its end point. If the fitting hypothesis does not account for this, unphysical values for $m^2_{\nu_e}$ are obtained. BELESEV 95 obtain their value for $m^2_{\nu_e}$ and limit for m_{ν_e} (4.35 eV at 95% CL) under the assumption that a certain narrow region is free of both high-energy and low-energy anomalies. Including the endpoint accumulation (they find no low-energy anomaly), STOEFFL 95 find a value for $m^2_{\nu_e}$ which is more than 5 standard deviations negative, and report a Bayesian limit of 7 eV for m_{ν_e} which is obtained by setting $m^2_{\nu_e} = 0$. Given the status of the tritium results, we find no clear way to set a meaningful limit on m_{ν_e}. On the other hand, a mass as large as 10–15 eV would probably cause detectable spectrum distortions near the endpoint.

The spread of arrival times of the neutrinos from SN 1987A, coupled with the measured neutrino energies, should provide a simple time-of-flight limit on m_{ν_e}. This statement, clothed in various degrees of sophistication, has been the basis for a very large number of papers. The LOREDO 89 limit (23 eV) is among the most conservative and involves few assumptions; as such, it is probably a safe limit. We list this limit below as "used," but conclude that a limit about half this size is justified by the tritium decay experiments.