The mass of the $\tau$ neutrinos

E.L. Koschmieder

Center for Statistical Mechanics, The University of Texas at Austin
Austin, TX 78712 USA

We have shown previously that the mass of the muon neutrino can be determined from the energy released in the decay of the $\pi^\pm$ mesons, and that the mass of the electron neutrino can be determined from the energy released in the decay of the neutron. We will now show how the mass of the tau neutrino can be determined from the decay of the $D^\pm$ mesons.

1 Introduction

As we have shown with the standing wave model of the stable mesons and baryons [1] it follows from the decay of the $\pi^\pm$ mesons that the mass of the muon neutrinos $\nu_\mu$ and $\bar{\nu}_\mu$ must be $m(\nu_\mu) = m(\bar{\nu}_\mu) = 47.5 \text{ meV}/c^2$. We have also found in [1] that it follows from the decay of the neutron that the mass of the antielectron neutrino $\bar{\nu}_e$ should be $m(\bar{\nu}_e) = 0.55 \text{ meV}/c^2$. We have to correct this value whose calculation was based on the assumption that the neutron, whose mass is $\approx 2K^\pm$, is the superposition of a $K^+$ and a $K^-$ meson. However, our investigation of the spin of the mesons and baryons [2] has shown that such a superposition does not produce spin $s = 1/2$, as is required. On the other hand, the superposition of two $K^0$ mesons has spin $s = 1/2$; actually the neutron must be the superposition of a $K^0$ and a $\bar{K}^0$ meson, because of conservation of strangeness in the strong interaction that created the neutron. According to the standing wave model the superposition of a $K^0$ and a $\bar{K}^0$ consists of neutrinos only and their oscillation energy. The neutrinos are arranged in a cubic lattice, each cell containing $\nu_\mu, \nu_\mu, \nu_e, \bar{\nu}_e$ neutrinos. The total number of the neutrinos in the neutron is $4N$, with $N = 2.854 \cdot 10^9$, twice as many neutrinos as if the neutron were a superposition of $K^+$ and $K^-$. That means that, when the neutron decays via $n \rightarrow p + e^- + \bar{\nu}_e$, $N$ antielectron neutrinos $\bar{\nu}_e$ share the difference $\Delta$ of the energy in the rest mass of the neutron and the energy in the rest mass of the proton $\Delta = 1.29332$ MeV. After the rest mass of the electron, also emitted in the decay
of the neutron, is subtracted from $\Delta$, and $\Delta - m(e)c^2 = 0.782321$ MeV is divided by $N$, not by $N/2$ as in [1], we find that the mass of the antielectron neutrino must be

$$m(\bar{\nu}_e) = 0.275 \text{ meV} / c^2.$$  

From the decay of the antineutron $\bar{n} \to \bar{p} + e^+ + \nu_e$ follows in principle that the mass of the electron neutrino should be $m(\nu_e) = 0.275 \text{ meV} / c^2$, or that $m(\nu_e) = m(\bar{\nu}_e)$.

2 The mass of $\nu_\tau$

We will now determine the mass of the $\tau$ neutrino $m(\nu_\tau)$ from the decay of the $D^\pm_s$ mesons in a way which is analogous to the way how we have determined the mass of $\nu_\mu$. The $D^\pm_s$ mesons decay via e.g.

$$D^+_s \to \tau^+ + \nu_\tau \ (6.4\%),$$

where $\tau^+$ is the positive $\tau$ meson or lepton. The decay of $D^-_s$ has the conjugate particles on the right hand side of (2). The 6.4 percentage of this mode of decay is, by a small margin, the most frequent of the leptonic modes of decay of $D^\pm_s$. The subsequent decay of $\tau^\pm$ is given by e.g.

$$\tau^+ \to \pi^+ + \bar{\nu}_\tau \ (11.06\%),$$

with the antitau neutrino $\bar{\nu}_\tau$. The percentage of this mode of decay of $\tau^\pm$ is likewise only one of the very many modes of decay of $\tau^\pm$.

If it is true, as we have postulated in [1], that the particles consist of the particles into which they decay, then it follows from Eqs.(2,3) that the $D^\pm_s$ mesons consist of $\nu_\tau$ and $\bar{\nu}_\tau$ neutrinos, plus the $\nu_\mu, \bar{\nu}_\mu, \nu_e, \bar{\nu}_e$ neutrinos in the $\pi^\pm$ mesons in Eq.(3). The cells of the lattice of the $D^\pm_s$ mesons contain 6 types of neutrinos, not 4 types as in the $\pi^\pm$ mesons. The cubic lattice used in the standing wave model can, however, be retained if we consider, instead of a simple cubic lattice as the NaCl lattice, a body-centered cubic lattice in which a particle different from the particles in the corners of the simple cubic cell sits at the center of each cell of the lattice. This seems to accomodate only 5 neutrino types, whereas we have found that there must be 6 neutrino types in the cells of the $D^\pm_s$ mesons. However, because of conservation of lepton numbers during the creation of the $D^\pm_s$ mesons it is necessary that a
number of antitau neutrinos equal to the number of tau neutrinos is present in the lattice. The antitau neutrinos can easily be accommodated in a lattice of body-centered cells in which the center particles are alternately tau neutrinos and antitau neutrinos.

As explained in [1] there must be \( N = 2.854 \cdot 10^9 \) neutrinos in the \( \pi^\pm \) lattice, and consequently there are \( N/4 \) simple cubic cells in \( \pi^\pm \). The number of cells in the \( \pi^\pm \) lattice and the lattice of the neutron seem to be the same, because the radii of the \( \pi^\pm \) mesons and the proton are, within the accuracy of the measurements, the same, and we assume that the size of the proton and neutron are the same. It appears that the superposition of a \( K^0 \) and a \( \bar{K}^0 \) meson creating a neutron does not change the size of the lattice of these particles, or the number of their cubic cells. We will therefore assume that the superposition of a proton, an antineutron and a \( \pi^0 \) meson creating the \( D_s^\pm \) mesons, with \( m(D_s^\pm) = 0.978 \cdot (m(p) + m(\bar{n}) + m(\pi^0)) \), does not change the number of the cells in the lattice either. In other words we assume that the size of the proton or neutron is the same as the size of the \( D_s^\pm \) mesons. If there are \( N/4 \) body-centered cells in the \( D_s^\pm \) meson then there must be \( N/8 \) tau neutrinos and antitau neutrinos each in the lattice of \( D_s^\pm \). The energy \( \Delta \) released in the decay \( D_s^{\pm} \rightarrow \tau^\pm + \nu_\tau \) (Eq.(2)) is given by

\[
\Delta = m(D_s^\pm)c^2 - m(\tau^\pm)c^2 = 191.51 \text{ MeV}.
\]

If this energy originates from the rest mass of all \( \nu_\tau \) neutrinos, respectively from all \( \bar{\nu}_\tau \) neutrinos, in the decay of \( D_s^\pm \) then it follows, with the number of \( \nu_\tau \) or \( \bar{\nu}_\tau \) neutrinos being \( N/8 \), that

\[
m(\nu_\tau) = m(\bar{\nu}_\tau) = 536.8 \text{ meV}/c^2 \approx 0.54 \text{ eV}/c^2.
\]

Since in the decay of \( D_s^+ \) only a single tau neutrino is emitted one must wonder why the energy \( \Delta \) released in the decay should be equal to the sum of the rest masses of all tau neutrinos in \( D_s^+ \). The first indication that \( \Delta \) is not the energy carried by a single tau neutrino in the \( D_s^+ \) meson comes from the magnitude of \( \Delta \) which amounts to practically 10% of the energy in the rest mass of \( D_s^+ \). This is incompatible with the basic tenet that there must be, according to Fourier analysis, a continuum of frequencies in a body created in a high energy collision of \( 10^{-23} \) sec duration, which does not make it possible that a single neutrino out of \( 10^9 \) neutrinos has a rest mass plus an oscillation energy amounting to 10% of the rest mass of \( D_s^\pm \). That the source of \( \Delta \) is the rest masses of all \( \nu_\tau \), respectively \( \bar{\nu}_\tau \), neutrinos can be inferred
from the disappearance of one of the two neutrino types in the secondary
decays following the primary decay of $D_s^{\pm}$. To be specific, the $\nu_\tau$ in the
decay of $D_s^{\pm}$ (Eq.(2)) does not appear neither in the decay of $\tau^{\pm}$ (Eq.(3))
nor in the subsequent decay of $\pi^{\pm}$ which is in also (3), nor in the decay of
the $\mu^{\pm}$ meson which follows. With the primary decay of $D_s^{\pm}$, (Eq.(2)), the
tau neutrinos seem to have been eliminated, which will certainly be the case
when the energy of the rest masses of all $\nu_\tau$ has been consumed by $\Delta$. This
process is analogous to the disappearance of one type of muon neutrino after
the decay of the $\pi^{\pm}$ mesons, as discussed in [1], where we have shown that
the oscillation energy of all neutrinos in $\pi^{\pm}$ is conserved in the decay, where
therefore the energy in the emitted neutrino can come only from the sum
of the rest masses of all neutrinos of the type of neutrino emitted in the decay.

Finally we want to show that the body-centered lattice of the $D_s^{\pm}$ meson
leads also to the correct spin $s(D_s^{\pm}) = 0$. We have shown in [2] and [3], e.g.
in context with the spin of the $\pi^{\pm}$ mesons $s(\pi^{\pm}) = 0$, that the spin of the
electric charge carried by the $\pi^{\pm}$ mesons is canceled by the sum of the spin
vectors of all neutrinos in the lattice. Of all the spin vectors of the $O(10^9)$
neutrinos in the cubic lattice of the $\pi^{\pm}$ mesons only the spin vector of the
central neutrino remains, which then cancels the spin vector of the electric
charge. The same applies for the body-centered lattice of the $D_s^{\pm}$ mesons. Of
the spin vectors of all neutrinos in the $D_s^{\pm}$ lattice only the spin vector of the
central neutrino, in this case of a $\nu_\tau$ or $\bar{\nu}_\tau$ neutrino, remains which cancels
the spin vector of the electric charge of $D_s^{\pm}$. Consequently $s(D_s^{\pm}) = 0$, as it
must be.

3 Conclusions

Making use of the decay of the $D_s^{\pm}$ mesons $D_s^{\pm} \rightarrow \tau^{\pm} + \nu_\tau (\bar{\nu}_\tau)$ we can show
that the mass of the tau neutrino must be $m(\nu_\tau) \approx 0.54 \text{eV}/c^2$. We also find
that $m(\nu_\tau) = m(\bar{\nu}_\tau)$.

REFERENCES

[1] E.L.Koschmieder, arXiv:physics/0211100 (2002),
Chaos, Solitons and Fractals 18,1129 (2003).
[2] E.L.Koschmieder, arXiv:physics/0301060 (2003), Hadr.J. (to appear).
[3] E.L.Koschmieder, arXiv:physics/0308069 (2003).