Neutrino Masses from Planck to Planck

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Abstract

Koide parameters for both neutrino and mirror neutrino triplets are examined in light of the CMB mirror neutrino correspondence. This note is just to record slightly improved rest mass predictions for the neutrinos.

In the 1980s, Koide predicted the τ lepton rest mass using the simple relation

$$\frac{\sqrt{m_e m_\mu} + \sqrt{m_\mu m_\tau} + \sqrt{m_\tau m_e}}{m_e + m_\mu + m_\tau} = \frac{1}{4} \tag{1}$$

involving the more accurately known electron and muon masses [1]. Later it was observed that 3×3 circulant matrices naturally parameterize such mass triplets [2]. The square roots of the three masses form an eigenvalue triplet for the Hermitian matrix

$$\frac{\sqrt{M}}{\sqrt{2}} \left(\begin{array}{ccc} r & e^{i\phi} & e^{-i\phi} \\ e^{-i\phi} & r & e^{i\phi} \\ e^{i\phi} & e^{-i\phi} & r \end{array} \right), \tag{2}$$

where $\sqrt{M}$ determines a unit scale. The charged lepton mass triplet is closely fitted by the values $\phi = 2/9$ and $r = \sqrt{2}$, with M the dynamical quark mass [3]. In [3], Brannen extended the Koide relation to the unknown neutrino rest mass triplet by allowing minus signs in (1). Using the known experimental constraints on Δm^2 values, noted below, a neutrino triplet is fitted with parameters

$$\phi_\nu = 2/9 + \pi/12 \qquad\qquad r_\nu = \sqrt{2} \tag{3}$$

and a suitably small value of M_ν. This is a normal hierarchy triplet, amenable to testing with current generation neutrino experiments. Koide triplets also exist for quarks [4][5], strengthening the argument for a universal 2/9 phase.

In any theory governing the parameters of (2) the phase ϕ, for a general triplet, may have several components. Although the phase conjugation $\phi \mapsto$

$\overline{\phi}$ leaves the mass triplet invariant, conjugation on a single non trivial phase component results in a new mass triplet. We consider the triplet

$$\phi_{\nu^*} = 2/9 - \pi/12 \qquad\qquad r_{\nu^*} = \sqrt{2} \tag{4}$$

as a secondary, right handed neutrino triplet. Such mirror neutrinos are a viable component of dark matter [6][7] and well studied in the context of neutrino anomalies. Assuming that $M_{\nu^*} = M_\nu$, it was observed some time ago that the central ν^* rest mass equals 0.00117 eV [4]. This mass corresponds closely to the local CMB temperature of $T = 2.725$ K, using the peak of the black body spectrum under Wien's law.

This result is a possibility in any cosmology that evolves the scales M in cosmological time, so that the CMB temperature always corresponds to a mirror neutrino mass. There is no doubling of the rest mass, as for an annihilation pair, so we view the CMB photon as a bosonization of the mirror neutrino.

The CMB data [8] indicate a precise CMB temperature of 2.7250 ± 0.0003 eV. Reversing the argument above, the resulting M_{ν^*} value is used for the original neutrino scale M_ν. In reality, the peak CMB temperature might be shifted somewhat from the simple Wien's law that is used in the temperature mass correspondence. From [9] we find that

$$mc^2 = 4.965114 \cdot kT, \tag{5}$$

where the dimensionless constant comes from differentiating Planck's law as a function of wavelength, and solving the transcendental equation $\exp(-x) = 1 - x/5$. The CMB mirror neutrino rest mass is then 0.001166 eV at a temperature of 2.7250 K, using accurate values for c and k. At this temperature, the standard neutrino rest masses take the values

$$\nu_1 = 0.05057 \text{ eV} \qquad \nu_2 = 3.8237 \times 10^{-4} \text{ eV} \qquad \nu_3 = 0.008888 \text{ eV} \tag{6}$$

for $M_\nu = 0.009973$ eV. This gives the range

$$\Delta m^2{}_{\text{atm}} = 2.478 \pm 0.002 \times 10^{-3} \text{ eV}^2 \qquad \Delta m^2{}_{\text{sol}} = 7.885 \pm 0.002 \times 10^{-5} \text{ eV}^2, \tag{7}$$

in rough agreement with current constraints. In [10], for the normal mass hierarchy that was predicted, they estimate $2.55 \pm 0.13 \times 10^{-3}$ eV^2 for $\Delta m^2{}_{\text{atm}}$ and 7.62×10^{-5} for $\Delta m^2{}_{\text{sol}}$. In [11] they give a value of $2.473 \pm 0.070 \times 10^{-3}$ eV^2 for $\Delta m^2{}_{\text{atm}}$. These oscillation results are open to clarification by future experiments, designed to measure the mass scale directly. Although one does not necessarily expect an exact Koide triplet for the neutrino masses, it is worth noting these predictions.

What of the other two rest masses in the mirror neutrino triplet? The heaviest mirror mass corresponds to a high redshift temperature, well before reionization, while the mirror scale occurs at roughly the reionization era.

Dungworth has noted recently [12] that the remaining mirror neutrino mass, at $0.89K$, may shed light on such mysteries as the local galactic haze in the CMB sky.

References

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