Origin of the Excess and No Excess of Electron-Neutrinos in MiniBooNE and MicroBooNE, Respectively

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Abstract: The atom-like structure of baryons, creation of virtual pairs, and different target-detector distances explain why, unlike the MiniBooNE data, the MicroBooNE results show no excess of electron-neutrinos and electron-antineutrinos. Our result, i.e. excess = 414.4 ± 59.0, is consistent with the MiniBooNE data.

1. Introduction

In the MiniBooNE, the muon-neutrinos, $\nu_\mu$, muon-antineutrinos, $\bar{\nu}_\mu$, electron-neutrinos, $\nu_e$, and electron-antineutrinos, $\bar{\nu}_e$, are produced by colliding protons to a beryllium target. A neutrino detector (it is a spherical tank filled with mineral oil and its diameter is 12.2 m) is placed at distance $L_{\text{Mini}} \approx 541 \pm 6.1$ m from the target (50 m air, 4 m steel and 487 m earth) [1].

MiniBooNE experiment was designed and built to search for neutrino oscillations ($\nu_\mu \rightarrow \nu_e$ and $\bar{\nu}_\mu, \text{anti} \rightarrow \nu_e, \text{anti}$) and to study interactions of neutrinos [1].

MiniBooNE results showed no evidence for muon-neutrino to electron-neutrino oscillations at low energy so a 2-neutrino oscillation interpretation is incorrect.

In MiniBooNE, a total $\nu_e$ plus $\nu_e, \text{anti}$ event excess of $N_{\text{Excess,Mini}} = 460.5 \pm 99.0$ events (4.7 $\sigma$) is observed, while the total number of events is 2437 [2].

On the other hand, in the MicroBooNE experiment, a neutrino detector (it is the 12.2-m long detector filled with liquid argon) is placed at distance $L_{\text{Micro}} \approx 470 \pm 6.1$ m from a beryllium target. The MicroBooNE data show no excess of electron-neutrinos and electron-antineutrinos [3]. Unlike the MiniBooNE, the MicroBooNE distinguishes electrons from photons.

A sterile neutrino could explain the MiniBooNE excess but the MicroBooNE experiment shows no hint of sterile neutrino. Notice that the Scale-Symmetric Theory (SST) [4] shows that sterile neutrinos do not exist.

We still need to explain the MiniBooNE excess.

Here we show that the atom-like structure of baryons, creation of virtual pairs, and different target-detector distances explain both the MiniBooNE excess and lack of such an excess in the MicroBooNE data.

We show that the neutrino-baryon interactions are crucial. We incorrectly interpret the single photon events from neutral current (NC) [5]

$$\nu (\bar{\nu}_{\text{anti}}) + N \rightarrow \nu (\bar{\nu}_{\text{anti}}) + N + \gamma,$$

where $N$ denotes a baryon.
In [5], authors conclude that photon emission processes from single-nucleon currents cannot explain the excess of the signal-like events observed at MiniBooNE. In the MiniBooNE experiment we observe following number of the NC events, $N_{\text{NC}}$, [2]

$$N_{\text{NC}} [\Delta(1232) \rightarrow N\gamma \text{ radiative decay}] = 172.5 \pm 24.1 + 34.7 \pm 5.4 =$$

$$= 207.2 \pm 29.5 \ . \ (2)$$

According to SST, the $\Delta(1232)$ resonance consists of nucleon and a charged vector boson $S_{(4-),d=2} \approx 298 \text{ MeV}$ or neutral boson $S_{(o),d=2} \approx 297 \text{ MeV}$ in the $d = 2$ state (see Section 2.22 and Table 1 in [4]). When the $d = 2$ boson is charged then it can create on the $d = 2$ orbit a virtual muon-antimuon ($\mu^+\mu^-$) virtual pair. When such a virtual pair interacts with a muon-neutrino then there is created a pion-muon $\pi^+\mu^-$ pair.

Moreover, SST shows that due to the tremendous non-gravitating energy frozen in each neutrino, neutrinos cannot oscillate – neutrinos in interactions with matter, carriers of energy, and the SST absolute spacetime can be exchanged for other neutrinos or they can force appearance of additional neutrinos [4] as it is showed, for example, in Section 2. Such phenomena lead to an illusion that neutrinos oscillate.

We must add also that the neutrino-antineutrino pairs with opposite weak charges of the components are the virtual photons or they carry energy of real photons [4]. In the composite photons, the neutrino-antineutrino pairs are entangled and each pair can be in different energetic states – it is a quantum/classical superposition but notice that it is not the orthodox quantum superposition which according to SST does not exist [4]. Emphasize also that the entangled neutrino-antineutrino pairs in a photon, due to the SST quantum/classical superluminal entanglement, can exchange their rotational energies so there can be a collapse of wavefunction of composite photon.

2. The neutral-current $\Delta(1232) \rightarrow N\gamma$ radiative decay

In the orthodox physics, the single photon events from neutral current (NC) are defined by expression (1). In SST, we can modify such an event

$$\nu_\mu + \Delta(1232) \rightarrow [(\mu^+\mu^-)_{\text{virtual},d=2} + \nu_\mu] + \Delta(1232) \rightarrow$$

$$\rightarrow \pi^+\mu^- + N + \gamma \rightarrow$$

$$\rightarrow [\nu_e + \nu_{e,\text{anti}} + \nu_\mu + \text{virtual photons}] + N + \gamma , \ (3)$$

where $\pi^+ \rightarrow e^+ \nu_e \nu_{\mu,\text{anti}} \nu_\mu$ and $\mu^- \rightarrow e^- \nu_{e,\text{anti}} \nu_\mu$.

In the $\pi^+\mu^-$ pair cannot be two or more the same neutrinos (there are two $\nu_\mu$) so there is created a virtual photon

$$\gamma_{\text{virtual}} \equiv \nu_{\mu,\text{anti}} \nu_\mu \ . \ (4)$$

Also the virtual $e^+e^-$ pair decays into virtual photons. We do not detect the virtual photons. Similar considerations are for the muon-antineutrino
\[ \nu_{\mu,\text{anti}} + \Delta(1232) \to [(\mu^+ \mu^-)_{\text{virtual,d}=2} + \nu_{\mu,\text{anti}}] + \Delta(1232) \to \]
\[ \mu^+ \pi^- + N + \gamma \to \]
\[ [\nu_e + \nu_{e,\text{anti}} + \nu_{\mu,\text{anti}} + \text{virtual photons}] + N + \gamma , \quad (5) \]

where \( \mu^+ \to e^+ \nu_e \nu_{\mu,\text{anti}} \) and \( \pi^- \to e^- \nu_{e,\text{anti}} \nu_{\mu,\text{anti}} \).

In the \( \mu^+ \pi^- \) pair cannot be two or more the same neutrinos (there are two \( \nu_{\mu,\text{anti}} \)) so there is created a virtual photon

\[ \gamma_{\text{virtual}} \equiv \nu_{\mu,\text{anti}} \cdot \quad (6) \]

3. **The SST \( \nu_e \) plus \( \nu_{e,\text{anti}} \) excess**

The difference between expression (1) and (3) or (5) which can be observed in a detector is

\[ \text{Difference} \equiv \nu_e + \nu_{e,\text{anti}} \]

so from formula (2) we obtain

\[ \text{Excess} = 2 N_{NC} = 414.4 \pm 59.0 . \quad (8) \]

This SST value is consistent with the MiniBooNE data.

4. **Effective range, \( R_{\text{eff}} \), for the decay of the virtual muon-antimuon pair, \((\mu^+ \mu^-)_{\text{virtual}}\), produced in the \( d = 2 \) state**

Effective range for the decay of the virtual muon-antimuon pair produced in the \( d = 2 \) state is defined as follows

\[ R_{\text{eff}} = v_{d=2} \tau_{\text{muon}} , \quad (9) \]

where \( v_{d=2} = 0.6403 \text{c} \) (c is the speed of light in “vacuum”) is the relativistic speed of the \( \pi^+ \) in the \( \pi^+ \mu^- \) pair in the \( d = 2 \) state (see formula (2.5.3) in [4]), and \( \tau_{\text{muon}} \) is the relativistic lifetime of the \( \mu^- \) in the \( \pi^+ \mu^- \) pair.

According to SST, the \( d = 2 \) state is the ground state above the Schwarzschild surface for the strong interactions of pions with the core of baryons [4].

The lifetime of the charged pion in the rest, \( \tau_{\text{o,pion}} = 2.6033(5) \cdot 10^{-8} \text{ s} \) is much shorter than the lifetime of the muon in the rest, \( \tau_{\text{o,muon}} = 2.1969811(22) \cdot 10^{-6} \text{ s} \), [6], so we assume that the \( \pi^+ \mu^- \) pair decays into the \( \mu^+ \mu^- \) pair already in the \( d = 2 \) state. We assume also that the linear speed of the \( (\mu^+ \mu^-)_{\text{virtual}} \) pair is equal to \( v_{d=2} \).

The relativistic lifetime of a particle, \( \tau \), is defined as follows

\[ \tau = \tau_o [1 - (v / c)^2]^{-1/2} , \quad (10) \]

where \( \tau_o \) is the lifetime in the rest. From (9) and (10) we obtain

\[ R_{\text{eff}} = v_{d=2} \tau_{\text{o,muon}} [1 - (v_{d=2} / c)^2]^{-1/2} = 549.0 \text{ m} . \quad (11) \]
5. Why the excess was not observed in MicroBooNE?

The effective range for the decay of the virtual muon-antimuon pair produced in the d = 2 state (549 m) is very close to the target-detector distance in MiniBooNE (~541 ± 6 m) so we observe the excess. But such effective range is about 80 m longer than the target-detector distance in MicroBooNE (~470 ± 6 m) so we do not observe the excess.

6. Summary

According to SST, sterile neutrinos do not exist. Within SST we showed also that the neutrino oscillations are an illusion. It leads to a conclusion that the observed excess of electron neutrinos in MiniBooNE cannot be explained via a sterile neutrino or neutrino oscillations. Here we showed that the excess is a result of incorrectly understood the neutral-current neutrino-baryon interactions – the internal structure of baryons and their dynamics are crucial to understand the excess.

We do not observe the excess in MicroBooNE because the target-detector distance is about 80 meters shorter than the effective range for decays of the virtual muon-antimuon pairs produced in the target.

We can verify our model in collisions of the muon-neutrinos with atomic nuclei for different target-detector distances. A positive result could validate the atom-like structure of baryons described in SST.

References