Some Unsettled Questions in the Problem of Neutrino Oscillations. Experiments

Beshtoev Kh. M.
Joint Inst. for Nucl. Research., Joliot Curie 6, 141980 Dubna, Moscow region,Russia

Abstract

It is shown that in order to register neutrino oscillations, it is necessary to see second or higher neutrino oscillation modes on experiments. For this purpose we can use the elliptic character of 1the Earth orbit. A special importance for study of the Earth neutrino sources, using big neutrino detectors, is stressed here. The analysis is showing that the SNO experimental results do not confirm the smallest of $\nu_e \rightarrow \nu_\tau$ transition angle mixings, which was obtained from analysis of the CHOOZ experimental data. It is also noted that there is contradiction between SNO, Super-Kamiokande, Homestake and the SAGE and GNO (GALLEX) data.

1. Introduction

In this article we will consider some unsettled questions in experiments on the problem of neutrino oscillations.

2. Experimental Observation of the Neutrino Oscillations

At present it supposed that the neutrino oscillations have been observed [1-3], In reality in these experiments there were observed only transitions between (the Sun or atmospheric) neutrinos. Since we presume that the neutrino oscillations do take place; therefore we must observe (Sun) neutrino oscillations in reality. Since the length of neutrino oscillations is great sufficiently, we cannot observe the higher modes in terrestrial experiment. But we have another possibility to observe the Sun neutrino oscillation using the fact that the Earth orbit is the elliptic one with:

Earth's perihelion $R_P = 147.117 \cdot 10^6 km$,
Earth's aphelion $R_A = 152.083 \cdot 10^6 km$, and
their difference ΔR is $\Delta R = 4.866 \cdot 10^6 km$.

Since the Sun neutrinos conclude all energies up to $15 MeV$, we must divide this energy spectrum into energy regions and observe these neutrino fluxes as a function of energy and the Ears's distances from the Sun. At these conditions we must observe the neutrino oscillations, in order to determine if the length of neutrino oscillation R_{osc} is bigger than the region Δ, where these (high energy)

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neutrinos are generated on the Sun i.e.

$$\Delta \sim 0.05 R_{sun} \sim 10^4 km, \tag{1}$$

$$R_{osc} > \Delta.$$

It is obvious that in these experiments it is impossible to register $\nu_\mu \leftrightarrow \nu_\tau$ oscillations, since their length, as we know from Super-Kamiokande experiments, is enough small . The Super-Kamiokande and SNO detectors are wholly fit for such observations.

3. The Earth Neutrinos

At present, there exist big detectors on the Sun and atmospheric neutrinos observation. The problem study of the Earth neutrino sources presents enormous interest; therefore, using the same detectors, it is possible to research the Earth neutrino sources. The Earth neutrino sources are the U and Th groups [4]. It is important that there is no necessary to reconstruct the detectors (besides of reduction of the neutrino registration threshold). It is only necessary to collect the data from the Earth, as it is fulfilled for the Sun neutrinos, but in the direction opposite to the Sun (it is also very important to solve the problem of origin of the background of the Sun neutrinos) . In this way we can obtain the Earth neutrino sources map using the detectors located in different places on the Earth surface.

4. The Problem with GNO (GALLEX), SAGE Data

As it was stressed above, the transitions between neutrinos with different flavor have been already observed, and the neutrino mixing angles are nearly maximal. The Super-Kamoikande [1], SNO [3], and Homestake [5] data (D) normalized on SSM calculations (see also [6]) are in good agreement.

Homestake 1970-1994, $E_{thre} = 0.814$:

$$\nu_e +^{71} Ga \to^{71} Ge + e^-, \qquad \frac{D^{exp}}{D^{BP2000}} = 0.34 \pm 0.03$$

Super-Kamiokande 1996-2001, $E_{thre} = 4.75 MeV$:

$$\nu_e + e^- \to \nu_e + e^-, \qquad \frac{D^{exp}}{D^{BP2000}} = 0.465 \pm 0.015;$$

SNO $E_{thre} = 6.9 MeV$

$$\nu_e + d \to p + p + e^-, \qquad \frac{D^{exp}}{D^{BP2000}} = 0.35 \pm 0.02,$$

$E_{thre} = 2.2 MeV$

$$\nu_e + d \to p + n + e^-, \qquad \frac{D^{exp}}{D^{BP200}} = 1.01 \pm 0.13,$$

$E_{thre} = 5.2MeV$

$$\nu + e^- \to \nu + e^-, \qquad \frac{D^{exp}}{D^{BP200}} = 0.47 \pm 0.05,$$

But, normalized on SSM [6] GNO (GALLEX) [7], SAGE [8] data are higher than above data on values $0.16 - 0.20$

GNO (GALLEX) 1998-2000, $E_{thre} = 0.233MeV$

$$\nu_e +^{71} Ga \to^{71} Ge + e^-, \qquad \frac{D^{exp}}{D^{BP200}} = 0.51 \pm 0.08;$$

SAGE 1990-2001, $E_{thre} = 0.233MeV$

$$\nu_e +^{71} Ga \to^{71} Ge + e^-, \qquad \frac{D^{exp}}{D^{BP200}} = 0.54 \pm 0.05;$$

Here we come to contradiction. Since the length of neutrino transitions (oscillations) is proportional to their energy; therefore, the neutrino energies are the smaller, the smaller is the length of transitions (oscillations), hence the norm of transitions (oscillations) at small energies must be the same as at the high one. It means that these experimental data have a contradiction. In order to solve this problem, probably, it is necessary to examine calibration of the last experiments. It is likely that the Standard Sun model [6] requires a revision in these energy regions. For registration of the full (the Sun) neutrino fluxes it is very important to organize an experiment with neutral currents in this energy region as it takes place in SNO detector. It is clear, that before taking decision on this problem, there is no sense to draw the allowed regions pictures.

5. The CHOOZ problem

On the France reactor experiment on $\bar{\nu}_e$ neutrinos, there is observed a very small angle mixing for $\bar{\nu}_e \to \bar{\nu}_\tau$ transitions [9]. If it is correct, then on SNO there must be observed [3] only the $\nu_e \to \nu_\mu$ neutrino transitions and the $\nu_e \to \nu_\tau$ transitions must be suppressed, i.e. the relation between ν_e and ν_μ neutrino fluxes must be equal

$$\Phi_{\nu_e} \simeq \Phi_{\nu_\tau}. \tag{2}$$

However, on the SNO experiments on neutral currents, we see approximately equal numbers of the three type of neutrinos.

$$\Phi_{\nu_e} \simeq \frac{1}{2}(\Phi_{\nu_\tau} + \Phi_{\nu_\mu}). \tag{3}$$

It is clear that the angle of $\bar{\nu}_e \to \bar{\nu}_\tau$ transition cannot be small. Since the distance from the reactor is small, the detector can register only a small mixing angle (in order to see a correct mixing angle, the detector must be in a distance which is a order of the oscillations length).

6. Conclusion

Though it is presumed that we see neutrino oscillations on the existing experiments, indeed there are registered transitions only between neutrinos. In order to register neutrino oscillations, it is necessary to see second or higher neutrino oscillation modes on experiments. For this purpose we can use the elliptic character of the Earth orbit. A special importance for study of the Earth neutrino sources, using big neutrino detectors, is stressed here.

The analysis is showing that the SNO experimental results do not confirm the smallest of $\nu_e \rightarrow \nu_\tau$ transition angle mixings, which was obtained from analysis of the CHOOZ experimental data. It is also noted that there is contradiction between SNO, Super-Kamiokande, Homestake and the SAGE and GNO (GALLEX) data.

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