Analysis of Upward Through Going Muon Events and Stopping Muon Events in the Virtual Super-Kamiokande Detector and the Neutrino Oscillation

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Abstract

We have constructed a virtual Super -Kamiokande in the computer and have obtained [Upward Through Going Muon Events] and [Stopping Muon Events]. We have analyzed them and have concluded that neutrino oscillation between ν_μ and ν_τ has not yet been confirmed.

1. Introduction

Among similar experiments on the existence of neutrino oscillation, the results obtained by Super-Kamionande(SK, hereafter) are regarded as one of the most important results, because of the definite conclusion of existence of the neutrino oscillation between muon neutrino and tau neutrino accompanied by sufficient statistics.

In the present paper, we examine the results on [Upward Through Going Events] and [Stopping Events] due to muon neutrinos in SK, by performing computer numerical experiment, namely by a kind of construction of the second SK, in the computer, the size and configuration of the detectors of which are as same as the real SK.

2. Numerical experimental procedure

We make numerical experiments as accurate as possible in the computer following physical processes which produce finally possible neutrino oscillation. We choose a neutrino from the atmospheric neutrino spectrum at the opposite to the Earth by random sampling. The neutrino thus selected is penetrating into the Earth, passing through the regions with different density and finally produces

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(anti-)muon from (anti-)neutrino interaction , whose energy is also determined from the produced muon energy spectrum from (anti-)neutrino by random sampling . The muon with definite starting point and with definite energy thus obtained is running toward our virtual Super-kamiokande, loosing its energy by bremsstrahlung , direct electron pair production and nuclear interaction together with ionization loss. Finnaly, the muon concerned may be [Upward Through Going Muon Events] or [Stopping Muon Events] or [Disappearing Events].

3. The results

The numerical computer experiments are carried out under the condition that the neutrino oscillation does not exist and exist with parameter of $\sin^2 2\theta$ and $\Delta m^2 = 3.2 \times 10^{-3} eV^2$ which are given in the SK[1].

In Figure 1, [Upward Stopping Muon Fluxes] (the first run in unit of 1247 live days) from our numerical experiments given as the functions of zenith angle together with data from the Super-Kamiokande. It is clear from the figure that the experimental data from SK agrees with our numerical experimental data without neutrino oscillation and disagree with corresponding data with neutrino oscillation, the parameters of which are obtained by SK.

In Figure 2, [Upward Through Going Muon Fluxes] (the first run in unit of 1268 live days) are given as the functions of zenith angle together data from SK. It is very clear that we could not discriminate the case without neutrino oscillation from the case with neutrino oscillation, the parameters of which are given by SK.

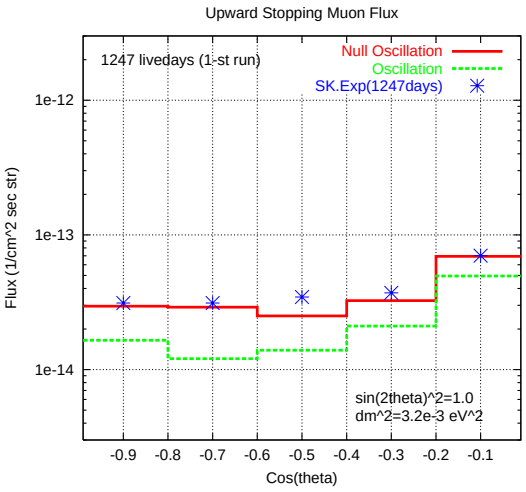

Fig. 1.

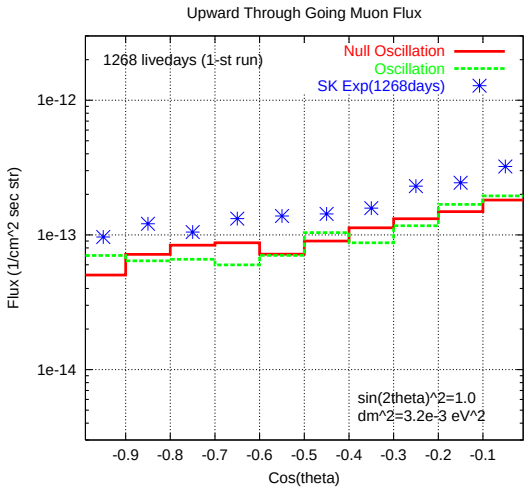

Fig. 2.

In Figure 3, [Upward Stopping Muon Fluxes] (the second run in unit of 1268 days) are given, corresponding to Figure1 and in Figure 4, [Upward Through Going Muon] (the second run in unit of 1247 days) are given, corresponding to Figure 4. Comparing Figure 1 with Figure 3 , it can be concluded that Upward Stopping Muon Flues by SK well agree with our numerical experiment in both absolute values and shape of the fluxes. Comparing Figure 2 with Figure4, it is easily concluded that we could not discriminate case without neutrino oscillation from the case with neutrino oscillation, the set of parameters of which are obtained by SK and absolute value of SK fluxes are about two times higher than our numerical computer experiment.

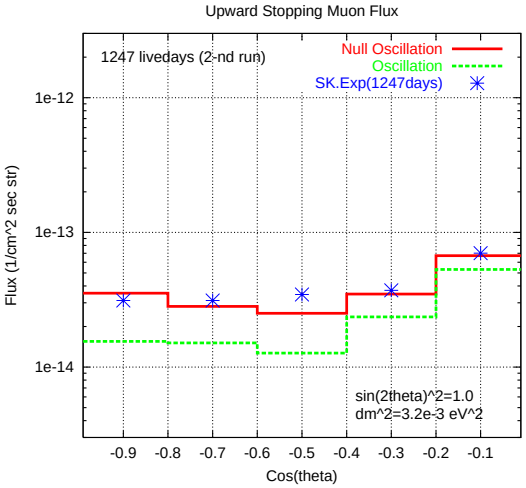

Fig. 3.

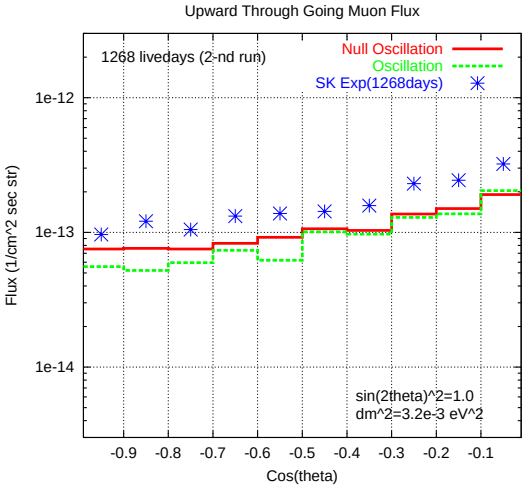

Fig. 4.

In Figure 5, [Upward Through Going Muon Fluxes] are given in the case that the atmospheric neutrino energy spectrum is increased by 50 % , corresponding to Figure 2 and 4. From the figure, it is clear that the absolute flux value of the SK data agree with both the cases with and without neutrino oscillation. Corresponding to Figure 5, [Upward Stopping Muon Fluxes] are given in Figure 6. the SK flux is neither agree with numerical experiment with neutrino oscillation nor with numerical experiment without neutrino oscillation from the point of the absolute vales. However, if we are forced to choose the case without neutrino oscillation or the case with neutrino oscillation, we ought choose the case without neutrino oscillation

4. Conclusions

As far as the analysis of both [Upward Through Going Muon] and [Upward Stopping Muon] are concerned, we should say that we never conclude

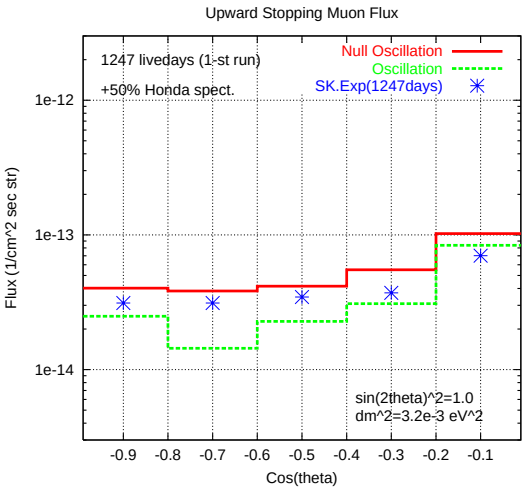

Fig. 5.

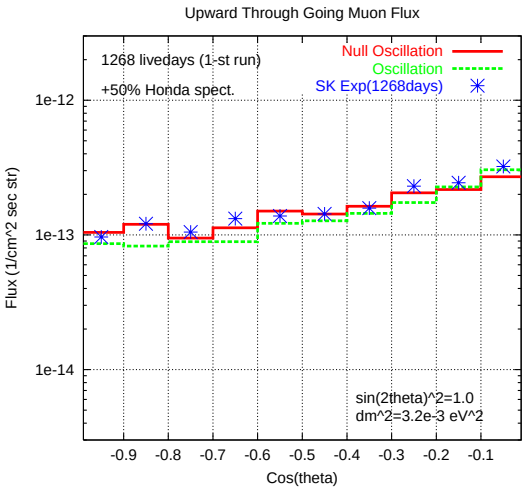

Fig. 6.

the positive existence of neutrino oscillation, the set of parameters of which are obtained by SK.

5. References

1. Habig A. 2001, ICRC2002, 5, 1061