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Standard solar model and electron-neutrino oscillations

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Introduction

The deficiency in the experimental measurements [1-5] as compared to the theoretical predictions about the solar neutrino flux made by using the standard solar model [6-8] is called the solar neutrino problem. Attempts to explain all these results by using high or low flux parameters based on standard solar models have not been successful. Wolfenstein suggested [9] that the problem could be solved in principle by assuming that at least one of the neutrinos

was massive and oscillations occurred between neutrinos of almost degenerate masses. The results were explained by taking neutrinos as massive and making use of MSW mechanism based on neutrino oscillations. However, all the terrestrial experiments [10], except the LSD experiment [11] whose results have not yet transcended the limits of statistical errors, performed to detect the flavour transformation of neutrinos due to their oscillations do not give any evidence for oscillations.

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Discussion and Conclusion

The Sudbury Neutrino Observatory (SNO) experimental results [12] are going to play an important role in determining the validity of various models. This

set up will measure the electron-neutrino flux as well as the total flux of neutrinos of all flavours. The data taking started in May 1999 and the data analysis is now in progress. The results may be announced in a few weeks time.

There are three possibilities which we we should consider:

1. The oscillations do occur and the experimental results show that the flux of mu- and tau-neutrinos more or less compensates the decrease in the flux of electron-neutrinos, as noticed experimentally with respect to the predictions of Bahcall et al [6]. This will establish the above-mentioned model along with the concept of electron-neutrino oscillations.

2. The oscillations do not occur at all. It rules out not only the high flux but also the low flux model of, say, Dar and Shaviv[8]. For water detector, this low flux model already predicts a flux which is very much consistent with the experimental data. Therefore, as far as water is concerned, this model asserts that there will be no neutrino oscillations. Because, otherwise, with water detector the theoretical result will become smaller than the experimental value. But what about other experiments with chlorine and gallium as detectors? The predicted electron-neutrino flux values of the low flux model are still much greater than the experimental values and therefore if theory is to agree with experiment, oscillations must occur. However, we may notice that although the oscillations do not occur at neutrino energy of about 5 GeV or greater, the oscillations may occur for lower energy neutrinos. Thus a new experiment will be required to give the final verdict on the low flux standard solar model. Naturally, at present, we have to consider some other phenomenon to solve the puzzle.

3. The third possibility is that SNO exhibits that oscillations do occur but are not sufficient enough to compensate the difference between the theory and the experiment. Some of the electron-neutrinos transform into neutrinos of other flavours, but the transformation is not sufficient enough. This would indicate that in addition to oscillations some other phenomenon is also in process and affects the neutrino flux.

The physics community is eagerly awaiting the SNO results.

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