KamLAND: Examination of the LMA Solution with Reactor Neutrinos

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Abstract:

The solar neutrino deficit has been a longstanding unsolved problem for almost 30 years. However, the recent solar neutrino experiment, SNO detected evidence that solar neutrino oscillations caused this deficit. The next experimental step is to determine the oscillation parameters. Based on the solar neutrino measurements to date, among the most plausible parameters within the hypothesis of two-flavor oscillations are $\sin^2 2\theta \sim 0.75$ and $\Delta m^2 \sim 2 \times 10^{-5}$ eV^2 commonly referred to as the large mixing angle solution, LMA. This parameter set is accessible by a laboratory test, using reactor neutrinos with a baseline on the order of more than 100 km. KamLAND (Kamioka Liquid scintillator Anti-Neutrino Detector) is just the experiment aimed at examining the oscillation parameters in the LMA region.

KamLAND sits at the site of the old Kamiokande experiment, the 3000 m^3 water Cherenkov detector that played a leading role in the study of neutrinos produced via cosmic rays and which also contributed to the subject of neutrino astronomy. The KamLAND design consists of a series concentric spherical shells containing from inside to outside, 1000 tons of ultrapure liquid scintillator, paraffin oil and water. An array of 1879 photomultiplier tubes (PMTs), 1325 of which are specially developed 17-in. PMTs and 554 of which are the old Kamiokande 20-in. devices, view the scintillation light generated within the liquid scintillator. The detector construction took about 5 years and the data taking started on January 22, 2002.

From the data analysis so far the detector has demonstrated performance more than adequate to detect reactor neutrinos through inverse beta-decay. Followings are the preliminary results. The contents of U, Th and ^{40}K inside the scintillator, the most serious background sources, are 8.0×10^{-18} g/g, 7.0×10^{-17} g/g and $<2.3 \times 10^{-16}$ g/g. This tells us the KamLAND 1000 ton liquid scintillator volume has become the lowest natural radioactivity space in the world. The energy is determined to within 1.8 % at 2.6 MeV at several positions inside the 5.5 m radius from the center and along the Z-axis. The energy resolution is 7.5% / $\sqrt{E}$. The detection efficiency for inverse beta-decay events is estimated to be 87.4 %. The total systematic error was been reduced to 6.1% above 2.6 MeV at present, although it is a little higher than the 5 % original goal value. KamLAND is clearly ready for detecting reactor neutrinos

More than 100 days live time data was accumulated by the middle of this August. The results of the reactor neutrino oscillation measurement can be presented at this conference if the analysis and detector calibration measurements continue on schedule.