論文内容の要旨

論文題目　Precise Measurement of Solar Neutrinos with Super-Kamiokande III
(スーパーカミオカンデ３における太陽ニュートリノの精密測定)

氏名　池田一得

New solar neutrino measurements with the Super-Kamiokande detector are reported. The main motivation of this thesis is to observe the spectrum distortion of solar neutrinos caused by the matter effect of neutrino oscillation in the Sun (MSW effect).

The data for this thesis were taken between August 2006 and August 2008, during the third phase of Super-Kamiokande (SK-III). Two neutrino samples are used in this thesis. The first one with total electron energy between 6.5 and 20MeV has a total livetime of 547.9 days. The second, with total electron energy between 4.5 and 6.5MeV has a total livetime of 298.2 days after rejecting high background periods caused by radioactive impurities accidentally injected into the detector.

With improved detector calibrations, a full detector simulation, and analysis methods, the systematic uncertainty on the total neutrino flux is estimated to be ±2.3%, which is about two thirds of the systematic uncertainty in the first phase of Super-Kamiokande (SK-I). The observed ^{8}B solar flux in the 5.0 to 20MeV electron energy region is 2.28 ±0.04(stat.)±0.05(sys.)× $10^6 cm^{-2} sec^{-1}$, in agreement with previous measurements. The day-night asymmetry is measured to be A_{DN}=-0.057±0.031(stat.)±0.013(sys.). In the 4.5-5.0 MeV region, the observed flux is $2.14^{+0.56}_{-0.54}$(stat) $10^6 cm^{-2} sec^{-1}$ (stat) and is consistent with the flux in the 5.0-20MeV region.

A global oscillation analysis is carried out using SK-I, II, and III, and is combined with the results of other solar neutrino experiments. The best-fit oscillation parameters are obtained with the world's best accuracy as $in^2\ \theta_{12} = 0.29\ ^{+0.024}_{-0.011}$ and $\Delta m_{12}^2 = 6.03^{+1.21}_{-1.67} \times 10^{-5}\ eV^2$. Combined with KamLAND result, the best-fit oscillation parameters are found to be $\sin^2\theta_{12} = 0.304\ ^{+0.017}_{-0.016}$ and $\Delta m_{12}^2 = 7.59^{+0.12}_{-0.39} \times 10^{-5}\ eV^2$. This parameter region corresponds to a ^8B flux of $5.08\ ^{+0.10}_{-0.07} \times 10^6 cm^{-2} sec^{-1}$.

The χ^2 value of spectrum fit with the solar plus KamLAND best-fit prediction is 26.7/20d.o.f. which is slightly better than 27.7/20d.o.f. with a flat shape. Although, this result is not statistically significant, it is estimated that the improved calibration and analysis methods will give a sensitivity of 3σ level discovery of the spectrum distortion within a few years together with the re-analysis of SK-I.