論文の内容の要旨

論文題目　^{8}B solar neutrino spectrum measurement using Super-Kamiokande IV
(Super-Kamiokande IV を用いた ^{8}B 太陽ニュートリノスペクトラム測定)

氏名　　中野　佑樹

The results of solar neutrino measurement using the fourth phase of the Super-Kamiokande detector, SK-IV, are presented. The main motivation of this thesis is to observe the matter effect of solar neutrinos oscillations.

For this purpose, the energy spectrum and day/night asymmetry measurements are performed. The data for this thesis were taken from September 2008 to April 2015. The livetime of the data sample is 2055.5 days. With the improvements of water circulation system, calibration methods and reduction cuts, the energy threshold for the analysis was lowered to 3.5 MeV in kinetic energy in SK-IV. In order to understand the detector performance for the lower energy range, the detection efficiency was precisely evaluated. In addition, a study for radon background events in water is performed. Also, systematic uncertainties for the flux and spectrum measurements are re-evaluated precisely. Finally, the total systematic uncertainty on the ^{8}B solar neutrino flux is obtained as $\pm 1.7\%$, which is the lowest among all SK phases.

Using the all events above 3.5 MeV, the ^{8}B solar neutrino flux in SK-IV is obtained as $\Phi_{^{8}\mathrm{B,SK4}} = 2.314 \pm 0.018(\mathrm{stat.}) \pm 0.039(\mathrm{syst.}) \times 10^{6}/\mathrm{cm}^{2}/\mathrm{sec}$, which is consistent with those of other phases. In the $3.5 - 4.0$ MeV region, the number of the extracted solar neutrino signal is $1299^{+156}_{-154}(\mathrm{stat.})^{+66}_{-64}(\mathrm{syst.})$ events, which is the most precise (statistically significant) measurement among the all solar neutrino experiments. Combining the measurements of all SK phases, the ^{8}B solar neutrino flux is $\Phi_{^{8}\mathrm{B,SK}} = 2.341 \pm 0.044(\mathrm{stat.} + \mathrm{syst.}) \times 10^{6}/\mathrm{cm}^{2}/\mathrm{sec}$. The ^{8}B solar neutrino fluxes during daytime and nighttime are compared and the day/night flux asymmetry is calculated as $A_{\mathrm{DN}} = -3.3 \pm 1.1(\mathrm{stat.}) \pm 0.8(\mathrm{syst.})\%$, which is 2.4σ away from zero.

A solar oscillation analysis is carried out combining SK-I through SK-IV. The obtained best fit oscillation parameters are $\sin^2\theta_{12,\mathrm{SK}} = 0.339^{+0.027}_{-0.023}$ and $\Delta m^2_{21,\mathrm{SK}} = 4.73^{+1.42}_{-0.81} \times 10^{-5}$ eV^2. In addition, a global oscillation analysis is performed combining the other solar neutrino experiments and KamLAND experiment. The obtained best fit parameters are $\sin^2\theta_{12,\mathrm{solar+KamLAND}} = 0.311 \pm 0.013$ and $\Delta m^2_{21,\mathrm{solar+KamLAND}} = 7.48^{+0.19}_{-0.17} \times 10^{-5}$ eV^2. By removing the θ_{13} constraint, the 3 flavor oscillation analysis is also performed. The best fit oscillation parameters are obtained as $\sin^2\theta_{12,\mathrm{solar+KamLAND}} = 0.309^{+0.014}_{-0.013}$, $\sin^2\theta_{13,\mathrm{solar+KamLAND}} = 0.027 \pm 0.015$, which is consistent with the results from the T2K and the short baseline reactor experiments.

The χ^2 values of energy spectrum fit to all SK data with a general quadratic fit, flat shape, solar global and solar plus KamLAND oscillation parameters are obtained to be 71.25, 71.42, 72.47 and 74.79 with d.o.f of 80, respectively. The flat shape is favored by $1.1 - 1.9\sigma$ level compared with the MSW prediction with best fit oscillation parameters. Although this result is not statistically significant, with the improvement of the detection efficiency and the reducing the radon background in the solar analysis, the "up-turn" of the energy spectrum is expected to be observed at $\sim 3\sigma$ level within about 6 years.