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主　論　文　の　要　旨

論文題目：Non-Standard Neutrino Interaction Analysis with Atmospheric Neutrino Data in Super-Kamiokande I-IV and the Design of the Hyper-Kamiokande Outer Detector
（Super-Kamiokande I-IV での大気ニュートリノデータの非標準ニュートリノ相互作用の解析と Hyper-Kamiokande Outer Detector の設計）

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論　文　内　容　の　要　旨

Neutrinos are the most abundant massive particle in the universe and they very rarely interact with anything, travelling the universe largely undisturbed. Due to their low interaction rates, neutrinos created in stars or in different galaxies can still reach us without being stopped. This makes them an excellent source to look far out into the universe and understand star formation and supernovae as well as back in time to understand the early universe.

As they rarely interact, large detectors are required in order to increase the chance of detecting a neutrino. One such large detector is called Super-Kamiokande or Super-K; it is a 50 kton tank filled with ultrapure water and 13,000 highly sensitive light detectors which are used to observe neutrino interactions. Super- K has been taking data since 1996 and has detected many neutrinos from various sources. Examining the energy, direction and flavour of the detected neutrinos allows us to determine their fundamental properties. All known fundamental particles and the interactions between them are described by a theory known as the Standard Model of particle physics. The theory is very successful and experiments have consistently verified its predictions. However, the Standard Model does not correctly describe the neutrino. For many years these particles were thought to be massless but experimental evidence shows that the particles do have mass. These particles come in three flavours and experiments have proven that a neutrino of one flavour can change into a neutrino of a different flavour.

This property of neutrinos is exciting as it indicates new physics beyond the Standard Model. Extensions to the Standard Model which account for the neutrino mass have been proposed; naturally, these extended models allow exotic interactions which are not allowed by the Standard Model.

These interactions are known as non- standard interactions (NSIs) and have not yet been observed. Observation of neutrino NSIs could indicate the existence of new particles or other exotic physics scenarios. In this thesis, 15 years of Super-K data has been analysed in order to look for possible non-standard interactions. No evidence of NSI was found and tight limits have been set on the possible strength of neutrino NSIs.

While the understanding of neutrino properties has advanced significantly in the last two decades, some questions remain open. Possibly the most important question is whether or not neutrinos and antineutrinos, their antimatter counterpart, behave in the same way. If they do not, then neutrinos could be the reason that the universe is dominated by matter while there is hardly any antimatter. To answer this question a much larger number of neutrinos must be detected which requires a larger detector.

In 2028 a new large detector Hyper-Kamiokande (Hyper-K), eight times larger than Super-K, will begin taking data. This thesis details the work carried out to design and eventually build Hyper-K. The detector will observe many neutrino events and will make use of a veto system to reject non-neutrino events. The work shown in this thesis is the design and optimisation of the Hyper-K veto detector.