The planned Hyper-Kamiokande detector will consist of an order of magnitude larger tank than the predecessor, Super-Kamiokande, and will be equipped with ultra high sensitivity photosensors. The Hyper-Kamiokande detector is both a “microscope,” used to observe elementary particles, and a “telescope,” used to study the Sun and supernovas through neutrinos. Hyper-Kamiokande aims to elucidate the Grand Unified Theory and explain the evolution of the Universe through the investigation of proton decay, CP violation (the difference between neutrinos and antineutrinos), and the observation of neutrinos from supernova explosions. The Hyper-Kamiokande experiment is an international research project aiming to become operational in the second half of the 2020s.

The discovery of neutrino oscillations in the Super-Kamiokande experiment in 1998, for which the 2015 Nobel Prize in Physics was awarded, led to the investigation and measurement of the properties of the neutrino which indicate the need for an update of the Standard Model. In 2001, the solar neutrino oscillation was discovered. In 2011, the T2K experiment, which used a neutrino beam from the high intensity accelerator J-PARC and the Super-Kamiokande detector, confirmed the third neutrino oscillation. Now that all neutrino oscillation modes have been confirmed, the field of neutrino research has opened up for further investigations and discoveries.

Based on the highly sensitive techniques for neutrino observation developed by Super-Kamiokande over the years, Hyper-Kamiokande represents a further improvement in sensitivity. Hyper-Kamiokande consists of a cylindrical tank, with a height of 60m and a diameter of 74m. The fiducial volume of the tank is approximately 10 times larger than that of the Super-Kamiokande detector. On the tank wall, 40,000 ultra high sensitivity photosensors will be installed in order to detect the very weak Cherenkov light generated in the water. Through the realization of the Hyper-Kamiokande experiment, we will lead neutrino research into the future.

Hyper-Kamiokande group
Mail : hk-public@km.icrr.u-tokyo.ac.jp
URL : http://www.hyper-k.org/
At the birth of the universe, it is thought that the four forces that govern our world (the strong, weak, electromagnetic, and gravitational forces) were unified in the form of a single force. When temperatures fell with the evolution of the universe, this unified force separated into the four forces.

The Grand Unified Theory, which governs the universe until about $10^{-10}$ seconds after the Big Bang ($10^{16}$ GeV, in terms of the energy of the universe), deals with energies too high to inspect directly through collision experiments in an accelerator. However, the Hyper-Kamiokande experiment can directly investigate the Grand Unified Theory by exploring proton decay. If protons decaying into more light particles can be observed, it means that all matter, including human beings, in the universe has a finite lifetime and will decay in the future.

Hyper-Kamiokande will elucidate neutrino properties such as the CP violation and approach the mysteries surrounding the evolution of the universe and the birth of life, through the observation of solar and supernova neutrinos.

**Neutrinos and Neutrino oscillations**

The matter in the Universe consist of elementary particles called quarks and leptons. For example, one proton, made of three quarks, and one electron, which is a kind of lepton, form a hydrogen atom. The neutrino is a kind of lepton without electric charge and exists in types; electron neutrino, mu neutrino and tau neutrino.

The three types of neutrinos mix with each other and can change their type. This phenomenon is called "Neutrino oscillation" and was discovered by Super-Kamiokande in 1998. The detailed study of neutrino oscillation enables us to reveal the properties of neutrinos.

The Standard Model, which describes the elementary particle system, seemed to be completed by the discovery of the Higgs boson particle. However, the information about neutrino mass and its mixing rate obtained by previous particle system, seemed to be completed by the discovery of the Higgs boson particle. However, the information about neutrino mass and its mixing rate obtained by previous observations, but also because it is an essential ingredient for determining the ordering of the neutrino masses is an important line of research not only because it increases the precision of CP violation measurements, but also because it is an essential ingredient for determining whether the neutrino is a Majorana fermion, a type of particle which is indistinguishable from its antiparticle.

**CP Violation Measurement**

Hyper-Kamiokande will investigate CP violation (i.e. the difference between particles and anti-particles) by observation of oscillations using neutrino/anti-neutrino beam from J-PARC accelerator. The present universe is filled with "matter" such as stars and human beings, but "anti-matter" is not seen. This imbalance between matter and antimatter might occur because of CP violation in neutrinos. We will investigate this asymmetry.

**Determining the Ordering of the Neutrino Masses**

Based on the observation of neutrinos oscillations, the differences between the three neutrino masses have been measured. However, it is not known whether the two masses that compose solar neutrinos are heavier or lighter than the third mass. Determining the ordering of the neutrino masses is an important line of research not only because it increases the precision of CP violation measurements, but also because it is an essential ingredient for determining whether the neutrino is a Majorana fermion, a type of particle which is indistinguishable from its antiparticle.

**Uncover the mystery of neutrino oscillation**

Hyper-Kamiokande will investigate CP violation (i.e. the difference between particles and anti-particles) by observation of oscillations using neutrino/anti-neutrino beam from J-PARC accelerator. The present universe is filled with "matter" such as stars and human beings, but "anti-matter" is not seen. This imbalance between matter and antimatter might occur because of CP violation in neutrinos. We will investigate this asymmetry.

**Verification of Grand Unified Theories**

In addition to natural neutrinos such as atmospheric and solar neutrinos, a high intensity and high quality neutrino beam from the J-PARC accelerator in Tokai, Ibaraki, may be used for precisely studying the properties of neutrinos such as CP violation.

Hyper-Kamiokande is expected to observe 30 times as many neutrinos as the T2K experiment after the increase of the J-PARC beam power.

**Cosmic Neutrino Observation**

Using cosmic neutrinos such as the neutrinos originating in the Sun, our galactic center, or a supernova explosion, we may study the stellar objects themselves. It is expected that Hyper-Kamiokande will enable us to elucidate the history of the universe.