Chapter one

INTRODUCTION

(1-1) Project outlines

In this project we introduced a review of the solar neutrino problem. In the history of this study it was recorded that the number of observed or measured neutrinos traveling from the Sun to Earth is usually less than the expected number that predicted from the theoretical estimations carried out using the standard solar model (SSM) and the equations in the model. We used the measurements from kamiokande experiment for the measured values of the neutrinos and we deduced that these values are less than the ones ought to be obtained from equations of the (SSM). In chapter one we'd introduced an introduction of the project revealing out the importance and the objectives of the project. In chapter two a description of the neutrino and its types and properties was presented, and we'd showed the solar system and also we presented an overview of the standard solar model. In chapter three we'd reviewed the solar neutrino problem. And in chapter four we described the kamiokande experiment. In chapter five we discussed the measurement results. Finally, in chapter six we concluded the project, and the references have been cited at the end of the project.

(1-2) Importance of the project

Since we reviewed the solar neutrino problem, it was well known that the solar neutrino is the only way to show the interaction in the core of the Sun.

(1-3) Problem of the project

Already in the history it was reported the so-called solar neutrino problem, we reviewed this problem and discussed our own believes about the way to resolve it.

(1-4) Objectives of the project

Objectives of this project are to study:

- The neutrino physics
- Solar neutrino problem
- The solution of the solar neutrino problem.

Chapter two

OVERVIEW OF NEUTRINO

(2-1) Introduction:

Definition of neutrino, its types and properties were presented here in this chapter.

(2-2) Definition of Neutrino

Neutrinos are neutral charged elementary particles. As leptons they are fermions and have a spin of ½ which was already postulated by Pauli. Neutrinos interact through the weak force, primarily, and through the gravitational force which is in most cases negligible, however. Since they do interact neither through the electromagnetic force nor through the strong force, their cross section is extremely small. On the one hand, this allows them to cross matter almost unaffected. Especially they are able to leave the Sun's core directly which make them to the only known information source about this region. On the other hand, it is very hard to verify these neutrinos here on Earth.

The Standard Model of particle physics describes neutrinos as mass less. According to the special theory of relativity this leads to the assumption that neutrinos must travel at the speed of light [2].

(2-3) Historical Background of the solar neutrino

The question 'How does the Sun shine?' presented the scientists of the 19th century with a great puzzle: there appeared to be no physically plausible mechanism that could account for the Sun's luminosity of nearly 4×10^{14} trillion Watts. The difficulty was not only to explain how to generate so a prodigious a power, but also to explain how it could be maintained for hundreds of millions of years. To illustrate the magnitude of the problem, in 1871 Hermann von Helmholtz computed that this power output is equivalent to that produced by burning 6 metric tons of coal per hour for every square meter of the Sun's photosphere! Various attempts were made to explain the

origin of sunlight; however, the world had to wait another half-century before a plausible mechanism was found.

A plausible mechanism, fusion, was first suggested by the British astronomer Sir Arthur Eddington in 1919, the same year he confirmed Einstein's prediction of the bending of light by gravity. However, although Eddington made the crucial suggestion that the fusion of hydrogen to helium could provide sufficient energy to account for the Sun's power he did not perform detailed calculations. The development of the fusion theory was initiated some twenty years later by Bethe and Crutch field on the eve of Europe's descent into a period of unfettered carnage [1]. Other important contributors were Fowler, Gamov, Vogt and von Weizs¨acker.

The Kamiokande experiment, which showed the first evidence that neutrinos

are actually coming from the Sun's direction, terminated its solar neutrino observation on 6 February 1995 [5].

(2-4) Astrophysics of the Sun

Our solar system consists of: the Sun and other celestial bodies such as: planets, moons and asteroids. Planets move around the Sun, and moons move around planets, the rest of those celestial bodies are all located around the Sun. The sun is the center of our solar system. The Sun is a star. It is a ball of hot, glowing gases. It is the only star that we can see during the day. At night we can see many stars in the dark sky. Some stars are bigger than our Sun and other stars are smaller. These stars are so far from the earth that they look like tiny points of light [2].
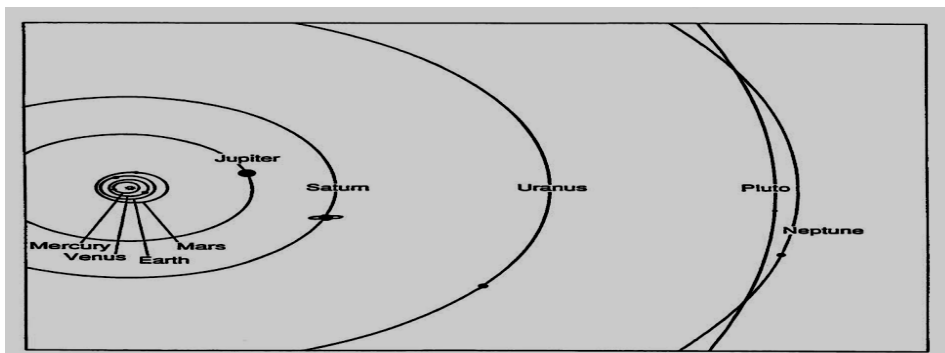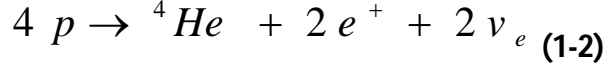

Fig.1 Our Solar System

The Sun is a main-sequence star at a stage of stable hydrogen burning. It produces an intense flux of electron neutrinos as a consequence of nuclear fusion reactions whose combined effect is [2]

$$4\ p \rightarrow\ ^4He\ +\ 2\ e^+\ +\ 2\ \nu_e \quad \text{(1-2)}$$

Positrons annihilate with electrons. Therefore, when considering the solar thermal energy generation, a relevant expression is

$$4p + 2e^- \rightarrow\ ^4He + 2e^+ + 26.73 MeV - E_\nu \quad \text{(2-2)}$$
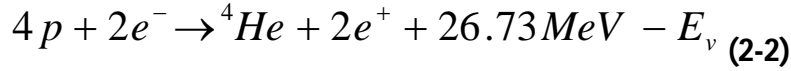
Where E_ν, represents the energy taken away by neutrinos, with an average value being $<E_\nu>$ 0.6 Mev. The neutrino producing reactions which are at work inside the Sun are enumerated in the first column in Table 1[3]. The second column in Table 1 shows abbreviation of these reactions. The energy spectrum of each reaction is shown in Fig. 1.

Reaction	Abbr.	Flux $(\text{cm}^{-2}\ \text{s}^{-1})$
$pp \rightarrow d e^+ \nu$	pp	$5.99(1.00 \pm 0.01) \times 10^{10}$
$pe^- p \rightarrow d\nu$	pep	$1.42(1.00 \pm 0.02) \times 10^8$
$^3\text{He}\ p \rightarrow\ ^4\text{He}\ e^+\nu$	hep	$7.93(1.00 \pm 0.16) \times 10^3$
$^7\text{Be}\ e^- \rightarrow\ ^7\text{Li}\ \nu + (\gamma)$	^7Be	$4.84(1.00 \pm 0.11) \times 10^9$
$^8\text{B} \rightarrow\ ^8\text{Be}^*\ e^+\nu$	^8B	$5.69(1.00 \pm 0.16) \times 10^6$
$^{13}\text{N} \rightarrow\ ^{13}\text{C}\ e^+\nu$	^{13}N	$3.07(1.00^{+0.31}_{-0.28}) \times 10^8$
$^{15}\text{O} \rightarrow\ ^{15}\text{N}\ e^+\nu$	^{15}O	$2.33(1.00^{+0.33}_{-0.29}) \times 10^8$
$^{17}\text{F} \rightarrow\ ^{17}\text{O}\ e^+\nu$	^{17}F	$5.84(1.00 \pm 0.52) \times 10^6$

Table 1: Neutrino- producing reaction in the sun, Their Abbreviation and their fluxes[3].

Observation of solar neutrinos directly addresses the theory of stellar structure and evolution, which is the basis of the standard solar model (SSM). The Sun as a well-defined neutrino

source also provides extremely important opportunities to investigate nontrivial neutrino properties such as nonzero mass and mixing.[2]
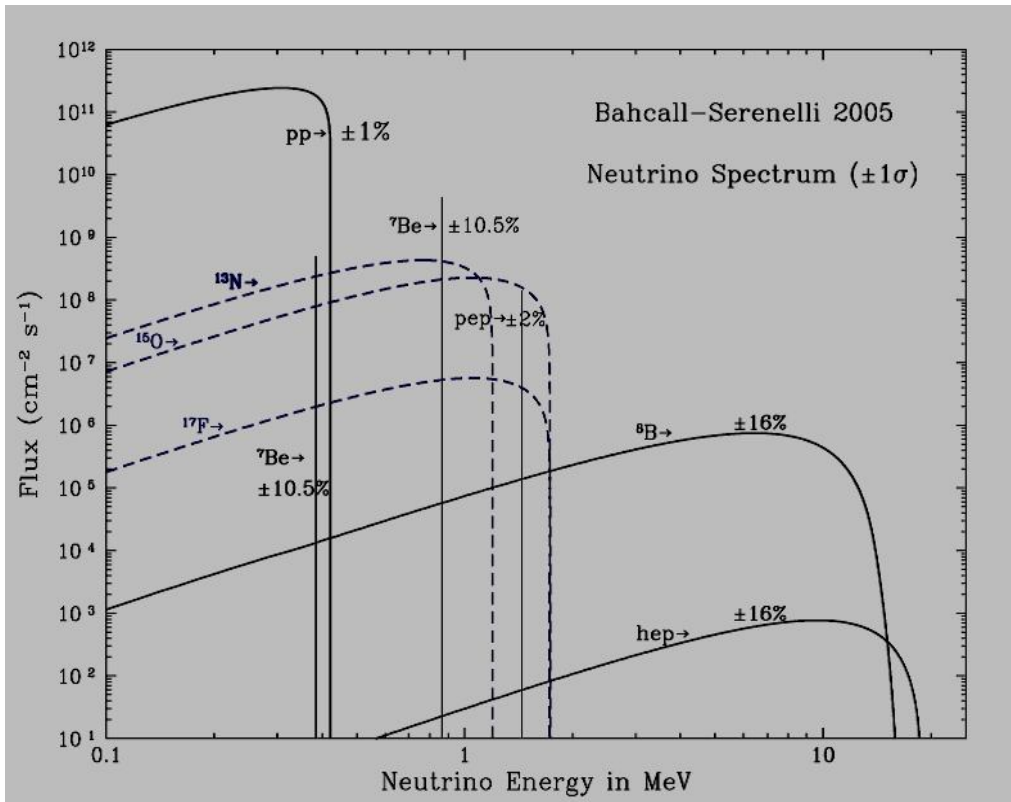

Fig.2 Solar neutrino spectrum predicted by BS05 standard solar model[2]

(2-5) Standard solar model

The standard solar model (SSM) is a mathematical treatment of the Sun as a spherical ball of gas (in varying states of ionization, with the hydrogen in the deep interior being a completely ionized plasmas). This model, technically the spherically symmetric quasi-static model of a star, has stellar structure described by several differential equations derived from basic physical principles. The model is constrained by boundary conditions, namely the luminosity, radius, age and composition of the Sun, which are well determined. The age of the Sun cannot be measured directly; one way to estimate it is from the age of the oldest meteorites, and models of the evolution of the solar system.[1] The composition in the photosphere of the modern-day Sun, by mass, is 74.9% hydrogen and 23.8% helium.[2] All heavier elements, called metals in astronomy, account for less than 2 percent of the mass. The SSM is used to test the validity of stellar evolution theory. In

fact, the only way to determine the two free parameters of the stellar evolution model, the helium abundance and the mixing length parameter (used to model convection in the Sun), are to adjust the SSM to "fit" the observed Sun.

Nuclear reactions in the core of the Sun change its composition, by converting hydrogen nuclei into helium nuclei by the proton-proton chain and (to a lesser extent in the Sun than in more massive stars) the Carbon-Nitrogen-Oxygen (CNO) cycle. This increases the mean molecular weight in the core of the Sun, which should lead to a decrease in pressure. This does not happen as instead the core contracts. By the Virial Theorem half of the gravitational potential energy released by this contraction goes towards raising the temperature of the core, and the other half is radiated away. By the ideal gas law this increase in temperature also increases the pressure and restores the balance of hydrostatic equilibrium. The luminosity of the Sun is increased by the temperature rise, increasing the rate of nuclear reactions. The outer layers expand to compensate for the increased temperature and pressure gradients.

(2-6) Solar neutrinos

The nuclear reactions occurring in the interior of the Sun produce an abundance of electron neutrinos _e; 95% of these are produced in the reaction

$$P + P \rightarrow {}^2H + e^+ + \nu_e \quad \text{(3-2)}$$
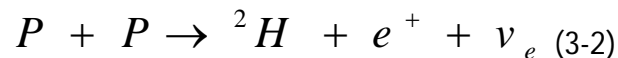
The Earth receives 6.6×10^{15} neutrinos per second and per square meter from the Sun. For about thirty years several experiments sought to detect these neutrinos, but all of them concluded that the measured neutrino flux is only about half the flux calculated using the standard solar model. Now this model is considered to be quite reliable, in particular owing to recent results from helioseismology. In any case, the uncertainties in the solar model cannot explain this "solar neutrino deficit." The combined results of three experiments have now shown with no possible doubt that this neutrino deficit is due to the transformation of _e neutrinos into other types of neutrino during the passage from the Sun to the Earth. These experiments show that the total neutrino flux predicted by the solar model is correct, but that the measured electron neutrino flux is too small. We shall show a simplified theory which gives the essential physics. We assume that there exist only two types of neutrino, the electron neutrino electron and the muon neutrino (in fact, there is also a third

type, the tau neutrino); the entire phenomenon takes place in a vacuum during the propagation from the Sun to the Earth (the propagation inside the Sun actually plays an important role).

(2-7) Neutrino Flavor Change in Matter

When an accelerator on the Earth's surface sends a beam of neutrinos several hundred kilometers to a waiting detector, the beam does not travel through a vacuum, but through Earth matter. Coherent forward scattering of the neutrinos in the beam from particles they encounter along the way can then have a large effect. Assuming that the neutrino interactions with matter are the flavor-conserving ones described by the Standard Model, a neutrino in matter can undergo coherent forward scattering from ambient particles in two ways. First, if it is a neutrino electron (ν_e) and only if it is a neutrino tau (ν_τ) can exchange a W boson with an electron. Coherent forward scattering by electrons via W exchange gives rise to an extra interaction potential energy V_W possessed by electron neutrinos in matter. Clearly, this extra energy from a lowest-order weak interaction will be proportional to the Fermi coupling constant (G_F). Equally clearly, this extra energy from $\nu_e - e$ scattering will be proportional to the number of electrons per unit volume (N_e). From the Standard Model, we find that:

$$V_W = +\sqrt{2 G_F} N_e \qquad (4\text{-}2)$$

And that this interaction potential energy changes sign if we replace them by: ν_e. Secondly, a neutrino in matter can exchange a Z boson with an ambient electron, proton, or neutron. The Standard Model tells us that any flavor of neutrino can do this, and that the amplitude for this Z exchange is flavor independent. The Standard Model also tells us that, at zero momentum transfer, the Z couplings to electron, like in fig 3 that show the neutrino flavor.
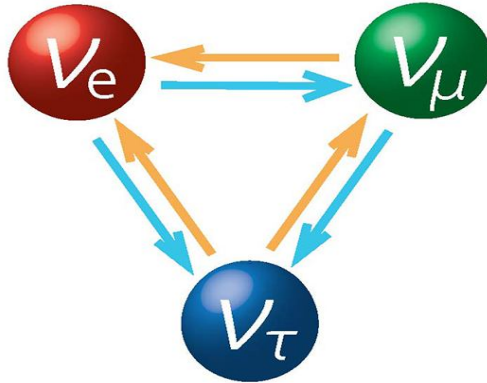
Fig (3) Flavor of neutrino

(2-8) Neutrino oscillation

The neutrino oscillation is a quantum mechanical phenomenon predicted by Bruno Pntecorvo [6]. Where by a neutrino created with a specific lepton flavor (electron, muon or tau) can later be measured to have a different flavor. The probability of measuring a particular flavor for a neutrino varies periodically as it propagates. Neutrino oscillation is of theoretical and experimental interest since observation of the phenomenon implies that the neutrino has non-zero mass, which is not part of the original standard model of particle physics. One possible explanation might be neutrino oscillations.

Like every particle neutrinos can be described as a wave function or a superposition of wave functions which is summarized by

$$|v_\alpha\rangle = \sum_i \bigcup_{\alpha i} |v_i\rangle \qquad (5-2)$$

We can only measure the resulting eigenstate on the left-hand side of Eq.(*5-2*), which we call flavor. It is generally accepted that there are three different flavors, electron, muon and tau neutrinos corresponding to the three charged leptons, i.e. $\alpha = e, \mu, \Gamma$.

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On the right-hand side we find the mass Eigen states $|\nu_\alpha\rangle = U_{ai}|\nu_i\rangle$ with $i = 1, 2, 3$ and the mixing matrix U_{ai} which is called the Pontecorvo-Maki-Nakagawa-Sakata (MNSP) matrix and is basically a rotation matrix with three Euler angles. It describes a charged-current interaction, i.e. a weak interaction mediated by the W boson, in the lepton sector [3].

(2-9) Neutrino mass

The neutrino mass much smaller than the mass of electron, the mass of neutrino approaches zero. So far scientists have not succeeded in the measurement of the mass, because the interaction with matter is very weak.

In the late 60's, physicists successfully unified the electromagnetic interaction and the weak interaction into the electroweak theory. The theory had predicted the mass of neutrino to be zero. Later, physicists tried to unify all the four fundamental interaction on nature and proposed the grand unified theory. This theory predicted the proton decay and that neutrino has a nonzero mass. As a half-life of proton decay lasts 1031 years and the interaction between neutrino and other particles is very week, it is very difficult to verify these two predications. At present, people have not found the strong evidence for the proton decay. However, there is no doubt the discovery of the rest mass of neutrino is a milestone for the establishment of the grand unified theory. Because the present stander model of particle physics is extremely rigorous and most of its prediction are already verified by experiments.

Chapter three

SOLAR NEUTRINO PROBLEM

(3-1) Introduction

In this chapter we reviewed the solar neutrino problem, and neutrinos detectors and its basic mechanism had also been illustrated.

(3-2) Solar neutrino problem

Neutrinos are produced in the cores of stars by processes such as the pp chain. Since neutrinos interact only weakly with matter, the speed out of the core of the star essentially unimpeded. Thus, if the neutrinos can be detected from a star, they provide a glimpse directly in to the processes going in the core of the star, while the visible light emitted at the surface may correspond to energies produced hundreds of thousands of years ago.

(3-3) Neutrino detectors

The only way to detect solar neutrinos is through their exceptionally rare collisions with ordinary matter although the vast majority of neutrinos pass right through matter more easily than light through a window pane, there is a finite chance that a neutrino will interact with a sub-atomic particle. When this slight chance is multiplied by the enormous quantities of neutrinos flowing from the sun, we conclude that once in a great while a solar neutrino will score a direct hit, and the resulting blast of nuclear debris can signal the existence of the otherwise invisible neutrino. The Sun produces neutrinos with a range of energies, and both the amount and energy of solar neutrinos depend on the particular reactions that produced them, and their expected flux [6].

The Possible Explanations of the Solar Neutrino Anomaly   once   experimental   difficulties have been ruled out, the scarcity of Sun could be explained in two general ways:

1. Perhaps we don't understand the Sun well enough internal better theory of the internal structure of the Sun would predict fewer neutrinos, in agreement with the measurements.
2. Perhaps we don't understand neutrinos well enough.

At the present time it is difficult to accept (1) because the standard solar model is very successful at the describing many other aspects of the Sun. Thus much recent attention has been focused on the possibility that neutrinos do something unusual. Most speculation centers on some variation of the theory that there are three kinds (called "flavors") of neutrinos, and that there passage through matter can cause one neutrino flavor to (oscillate) into another.

It can be shown that if this is arranged in just the right way it could account for the observed deficit of solar neutrinos. However, there is no direct proof yet that neutrinos oscillate in this manner so this remains a tentative explanation of what appears to be a real experimental inconsistency [8].

3-4 Solutions to the solar neutrino problem

What Is the Solution?

Solutions to the solar neutrino problem are usually classified in one of two categories, astrophysical or physical. Solutions that require a change in the way we think about the Sun are termed astrophysical solutions while solutions that require a change in the way we think about neutrinos are called physical solutions[8] .

3-4-1 Astrophysical Solutions

One way to solve the solar neutrino problem is to lower the central temperature of the Sun by a few percent. This will mean fewer high-energy nuclear reactions occurring in the solar core and thus, fewer neutrinos being produced and hence detected. There are a number of ways to lower the central solar temperature. Mixing will cause fresh fuel to be brought into the core, and thus a lower temperature will be needed to maintain equilibrium. Rotation, convection, or other instabilities such as the helium 3 instability could cause mixing in the core.

3-4-2 A Physical Solutions

Current theory in particle physics states that it is possible for neutrinos to transform from one type to another. The Mikheyev-Smirnov-Wolfenstein (MSW) effect claims that electron neutrinos may transform or oscillate into either muon or tauon neutrinos. Other theories state that left-handed neutrinos may process into right-handed neutrinos, or that neutrinos of one flavor and orientation may transform into neutrinos of another flavor and orientation. If these transformations take place in a vacuum, then they are called vacuum oscillations. Transformations taking place in matter are called, reasonably enough, matter oscillations. The neutrino experiments currently running on Earth only detect left-handed electron neutrinos. Therefore, if neutrino oscillations are taking place, then some, perhaps two-thirds, of the electron neutrinos produced by the Sun are being transformed into something that we are not detecting[9].

Chapter Four

EXPERIMENT OF SUPER KAMIOKANDE

4-1ntroduction

The target of the Experiment neutrino observatory counter (super kamiokande), study neutrinos solar, research analyzes the proton and neutrinos emerging earth .

This observatory built underground in a mine kamiokande in Japan.

4-2 Outline of super kamiokande

Super kamiokande is large water Cherenkov detector. The construction was started in 1991.

The super kamiokande detector consists of stainless-steel tank, 39m diameter and 42m tall, filled

with 50,000 tons of ultra pure water. The detector is located at 1000 meter underground in the kamiokande mine, Hida-city, JaSpan.

There is one of the purposes of the super kamiokande experiment is reveal the neutrino properties through the observation of solar neutrinos. In 1998, from the observation of atmospheric neutrinos we discovered neutrino oscillations which neutrinos are changing their types in flight. In 2001, solar neutrino oscillations were discovered by observation of the solar neutrino. The investigation of the neutrino properties will enable us to understand how matter was created in the early universe. By observation of solar neutrinos, we can know the activities inside of the Sun.

4-3 Details of the detector

4-3-1 The tank top

Upper side of tank in the left we find electrons huts and several calibration equipment are located on the tank of the super kamiokande.
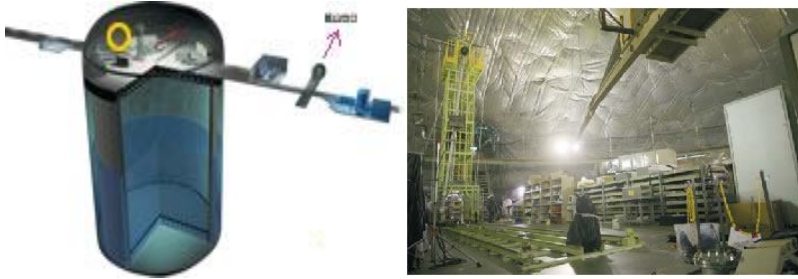

Fig4-1(The tank top)

The rock in the mine contains the radioactive material (radon).To avoid contamination of the radioactive material emitted from the rock, the wall is sealed by the polyethylene Mine guard

4-3-2 Electronics huts

The electronics system which read out the information of the signal sent from the photo – multiplier-tubes and the high voltage about 2000 volts power supplies is located. Electronics Huts
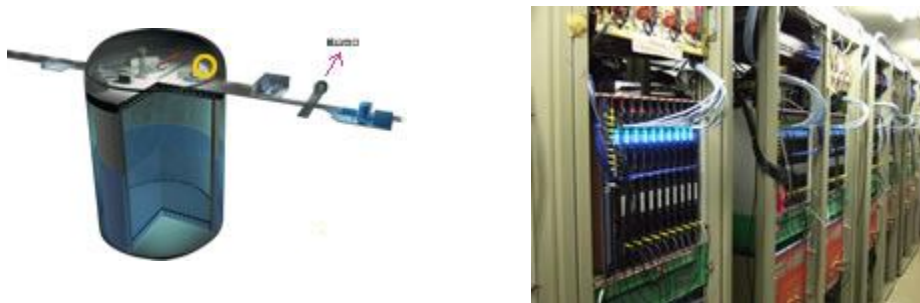
Fig 4-2(Electronics huts)

This electronics system digitizes the analogue information about the amount of detected charge and the hit timing from PMTs. New system of super kamiokande

Has recorded all the hits of each PMT which hits about 4500 a second for analysis.

4-3-3 Control room

In this control room, two researches do various checks during the first shift (8:30am-4:30pm). During the other shift, researches continue to check from the laboratory which is located in 15 min by car from the entrance of the mine.

Fig4-3(Control room)

Super-kamiokande continues to take data for 24 hours a day 365 days a year.

4-3-4 Water purification system

The super-kamiokande detector is filled with 50,000 tons of ultra-pure water. It is very important to keep the water clean to improve the detection precision.

The experiment uses the clean ground water .The further removal of small dusts , ions, bacteria and radon can reduce the scatter of Cherenkov light and background noise from radon decay products in the water .The water in the tank is continuously reprocessed in the cycle system. The typical number of particles of size greater than 0.1 micrometer in the water is reduced to100 particles/cc after purification.
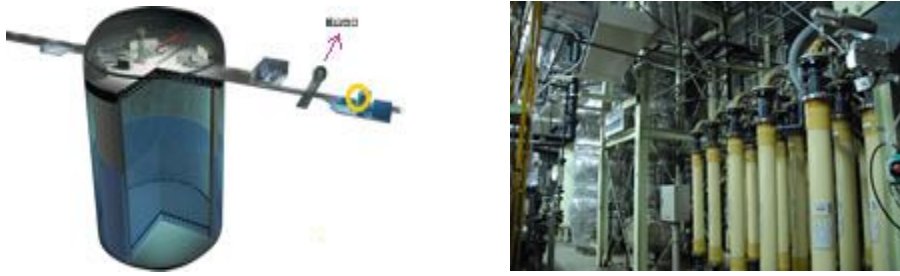
Fig 4-4(Water purification system)

4-3-5 Photo-Multiplier-Tubes (Inner detector)

The inward-facing 11,129 photo-sensors, called photo-multiplier-tubes (PMTs) are instrumented in the inner tank. The Cherenkov light emitted by charged particles running in water is detected by these sensors. The energy and direction of the charged particle is calculated by the information of the detected charge and timing. This PMT is developed with Hamamatsu-photonics.

The diameter of the photosensitive area is 20 inch (about 50 cm) and is largest in the world.

Fig4-3-5 Photo-Multiplier-Tubes (Inner detector)

The inner PMTs are instrumented at intervals of 70 cm and cover about 40% of the detector wall. The rest of the surface is covered with black polyethylene sheet which optically separates the tank to the inner part and the outer part.

4-3-6 Photo-Multiplier-Tubes (Outer detector)

In outer detector is optically separated into two concentric cylindrical regions by PMT support structures and pairs of opaque sheets.

The PMTs of the outer detector (OD) are smaller than those of the inner detectors and the diameter is 8 inch (about 20cm). The walls are covered with reflective white sheet.

Fig 4-4-6(photo –Multiplier-Tubes (outer detector)

The main purpose of the outer detector is to distinguish the neutrino events from the cosmic ray muon event. The cosmic ray muons are background sources of the neutrino observation. Because the neutrinos are electrically neutral, the Cherenkov light is emitted when the neutrinos scatter with the water.

4-3-7 Water tank

The super-kamiokande detector consists of a cylindrical stainless steel tank, 39.3 in diameter and 41.4m in height, and photo sensors called PMT installed to the detector wall. The detector is filled with 50 k tons of pure water.

The PMT support structure divides the tank into two distinct, optically isolated volumes, the inner detector and the outer detector.

This tank of water must be kept close because we must take data continuously.
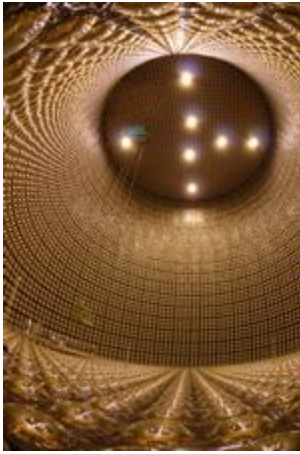
Fig 4-3-6 (water tank)

4-4 Event Display

How to See the Event Display?

The display shows the expansion of the cylindrical detector. The center larger figure is a display of the inner detector (ID) with its 11,129 20inch photomultiplier tubes and the smaller figure shows the data of outer detector (OD). The colored dots visualize information on which tubes got hit in the event on display. Two modes are possible: Color can either encode the charge (Q) registered at that particular tube or the time (T) when the tube was hit. Which mode of display was chosen for the particular event you are looking at can be determined from the entry "Current:" in the upper left corner of the display.
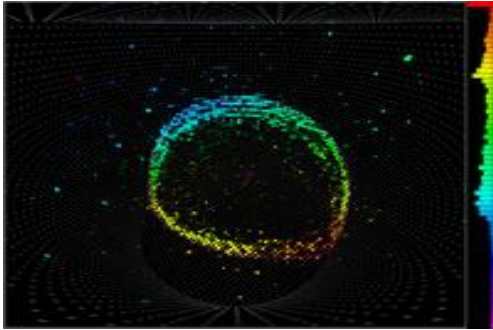
Fig 4-4 event display

The up picture is the event display of a muon neutrino detected by the Super-Kamiokande. The colored points indicate the quantity of the detected light by each PMT. The Cherenkov ring emitted by a muon is displayed.
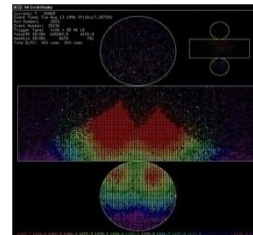
4-5 Muon Events

Super-Kamiokande detects about 2 Hz of cosmic ray muons. Some interesting images are shown here.
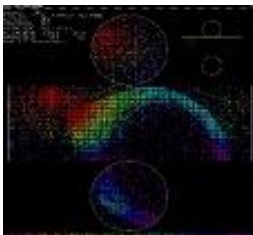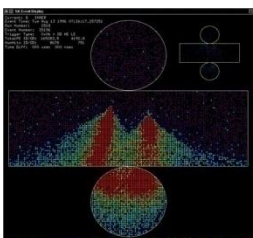

Stopping muon
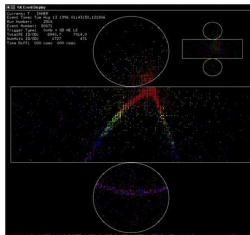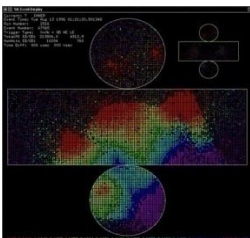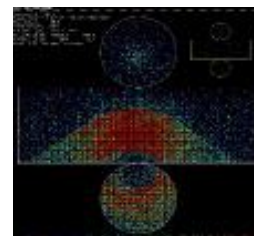

Corner edge clipping muon
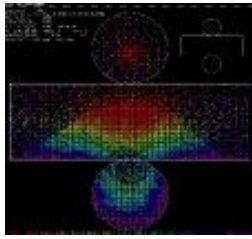

Double muon (Timing distribution)

Double muon (Charge distribution)

Triple `1muons

Stopping muon entering from the top

Stopping muon entering from the top   An electron emitted from muon decay

4-6 Neutrino Events

The neutrino events and the cosmic ray muon events are distinguished by the number of photons detected by the PMTs of the outer detector. When the cosmic ray muon enters the outer detector, the Cherenkov light is emitted immediately because the cosmic ray muon is a charged particle. The cosmic ray muon runs into the water and continues to emit the Cherenkov light, which is detected by the inner PMTs.

On the other hand, a neutrino itself does not emit the Cherenkov light because it is a neutral particle. When a neutrino interacts with the charged particle in water, the charged particle emits the Cherenkov light. Therefore in most case of neutrino events, only the inner PMTs have hits and the outer PMTs do not have hits. The outer PMTs are very effective to roughly distinguish neutrino events from charged particles such as cosmic ray muons.
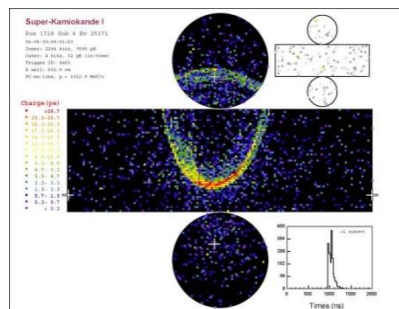

Fig 4-6-1muon neutrino

A Cherenkov ring occurred by a muon neutrino. A muon neutrino interacts with a nucleon in water and transforms to a muon. The outer detector has few hits in the right-upper display.
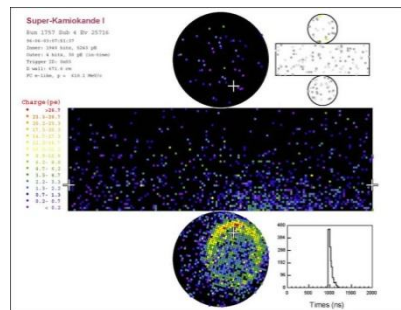

Fig 4-6-2 An electron neutrino

An electron neutrino event. An electron neutrino scatters an electron in water. The emitted electron generates an electromagnetic shower, leading to the fuzzy edge of the Cherenkov ring.

Chapter five

RESULTS AND DISCUSSION

5-1   Results of super kamiokande real time images

The results of the real time images of the events obtained from the super kamiokande website are recorded in a period of half hour starting from: 8:00 am to 8:30 am on July 16, 2014. A number of 84 images of the events were recorded some events were identified as neutrino muon, others are identified as neutrino electron, while the rest were classified as cosmic muons. Figures: 4-7-1 and 4-7-2 shows examples of the different types of the detected neutrinos during the observational period mentioned above.
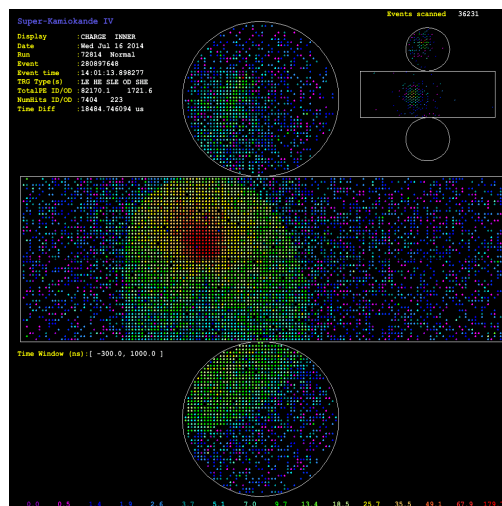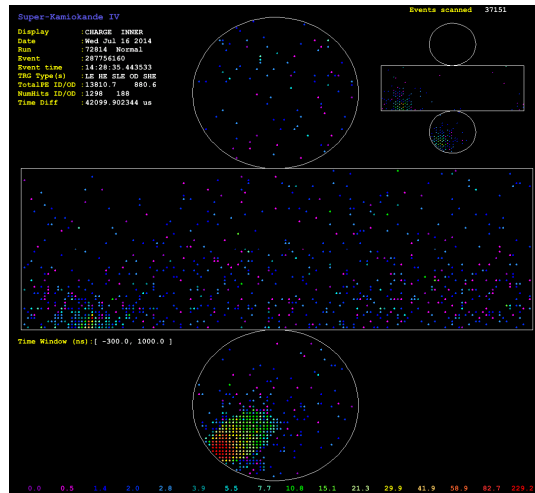

Fig 4-7-1neutrino muon

Fig4-7-2 neutrino electron

4-8 Discussions

In chapter four we described the super kamiokande, details of the detector :the tank top ,electronics huts ,control room, water purification system, photo-multiplier-tubes(inner detector),photo-multiplier-tubes(outer detector),water tank, event display, muon events and neutrino electron events , accordingly, our observation showed many images for the events for both neutrino electron and neutrino muon. This number detected of both events is deduced to be less than the number of neutrinos that left the Sun, this could be attributed to the well-known solar neutrino problem.

From our own point of view the discrepancy resulted in the number of detected neutrinos could be resolved by presenting new concepts in neutrino physics, alternatively, we support the Physical solution rather than the Astrophysical solution.

Chapter Six

CONCLUSION

6-1 Conclusion

In this project we'd studied a bit of the neutrino Physics, the solar neutrino problem and the solution of the solar neutrino problem. Using the experience of super kamiokande, we recorded 8 events of neutrino electron and 76 events of neutrino muon, the rest was found to be cosmic muon events. On classifying the events we used the description of events set by super Kamiokande experiment experts which is found on the official website of the super Kamiokande, this description is as follows: If the Cherenkov ring was clear we classify the event as neutrino muon or if the Cherenkov ring is fuzzy then we classify the event as neutrino electron. Accordingly to the puzzle of the solar neutrinos the number of neutrinos that coming from the Sun to the ground was found to be less than the original number.

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