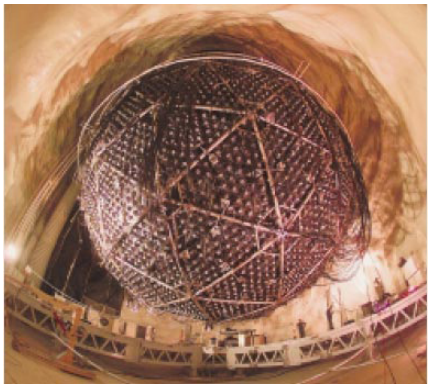
The World of Neutrinos

Postulated by Wolfgang Pauli since 1930, neutrinos remain mysterious entities today. According to the Standard Model, they belong to the lepton family. The complete lepton family consists of electrons, muons, taus, and three corresponding varieties of neutrinos: electron neutrinos, muon neutrinos, and tau neutrinos.

Neutrinos can originate from nuclear reactions such as beta decays (neutrons changing into protons and vice versa). From outside the Earth, neutrinos can come from supernovae (explosions of stars) and nuclear fusion reactions inside the Sun. These are called galactic neutrinos. The interaction between cosmic rays and Earth's atmospheric molecules can generate pions (very light particles) which are unstable and decay into muons and muon neutrinos. On Earth itself, neutrinos can be generated inside nuclear reactors and particle accelerators.

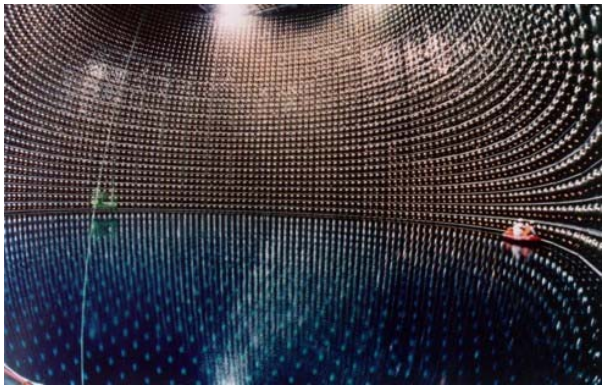
Physicists have found that neutrinos can change flavors. For example, a muon neutrino can change into an electron neutrino. This is called a neutrino oscillation. The significance of this is that neutrinos may not be massless as once thought. A neutrino in flight is actually a superposition of the three flavors (electron, muon, tau), but a detected neutrino can only be one of the three flavors. This is all very interesting to our understanding of the fundamental particles. The nature of the neutrino mass and oscillation is actively being investigated by many.

Being neutral and very light in mass, neutrinos fly around the universe without interacting very much. Since neutrino reactions are rare, it takes incredibly large machines to detect these elusive particles. There are several neutrino experiments around the world today. Some study galactic and atmospheric neutrinos (e.g., IceCube, SNO, and Super K), while some others concentrate on neutrinos made here on Earth (by accelerators or reactors), for examples BooNE and KamLAND.



SNO (Canada)

IceCube (Antarctica)



Super Kamiokande (Japan)

BooNE (USA)

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