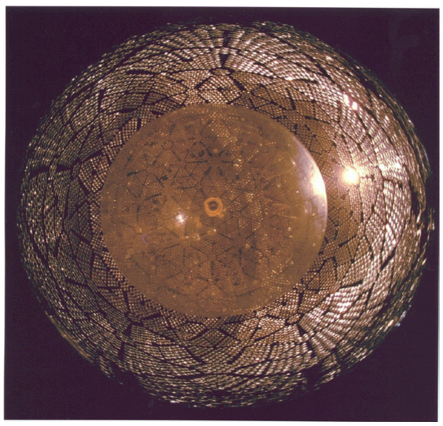
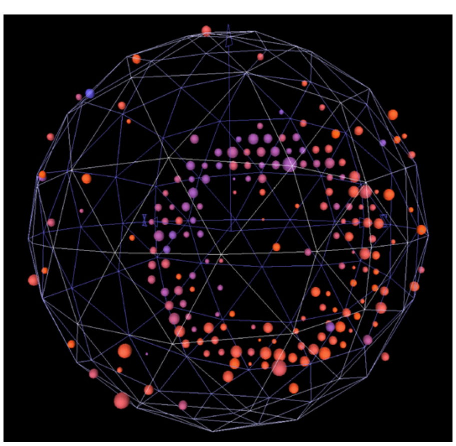
Neutrino

Small neutral particle





Neutrinos are members of the Standard Model, belonging to a class of particles called leptons. For a long time scientists believed neutrinos were massless and moved at the speed of light. However, physicists have found increasing evidence that these tiny particles in fact have mass, although much less than that of the electron. Right now we only know the upper limits on what the mass could be and the mass differences between flavors of neutrinos, although there are many current experiments designed to probe this question. The difficulty lies in the fact that neutrinos are extremely non-interacting and therefore hard to detect.

Neutrinos come from several sources. The majority of neutrinos were created during the first few fractions of a second after the big bang, approximately 15 billion years ago, when the universe was comprised of elementary particles. These neutrinos are very low energy; they are so low, in fact, that we cannot detect them. These, along with microwave radiation, constitute the cosmic background radiation that permeates the entire universe, creating a picture of the events immediately following the big bang. Other neutrinos are produced in stars such as our own sun. In its core four protons combine with two electrons to form a helium nucleus and two electron neutrinos.

There are man-made sources such as physics laboratories where we create them by smashing high energy particles into fixed or moving targets.

Neutrinos are a fundamental part of nature and we know relatively little about them. There are many important questions being asked by scientists around the world. What are the neutrino masses?
We now believe neutrinos rotate between different flavors, but how do they do so and for how long? What implications do oscillations have on the standard model? Neutrinos are produced by the same fusion reactions in the core of the Sun that produce the heat and light which makes life on Earth possible. The density of the Sun is so

great, it takes a million years for the light and heat produced by these reactions to travel the 700,000 km from the centre of the Sun to its surface (and then a mere 8 minutes for the light to travel the intervening 150 million kilometers from the Sun to the Earth).
Solar neutrinos on the other hand interact so rarely that they have almost no interactions inside the Sun and escape almost immediately and travel at nearly the speed of light. This property of neutrinos to pass through the Sun has allowed astrophysicists the opportunity to look into the heart of the Sun and study the solar furnace that powers it. At the same time, because the sun is such an enormous source of neutrinos (about 60 billion solar neutrinos pass through your thumb nail every second) it could be used to study the properties of neutrinos themselves. Experiments such as SNO have made measurements of parts of spectrum of neutrinos from the sun which have revealed new properties of the neutrino (that they undergo flavour oscillations) and confirmed to very good precision that we understand the mechanisms that make the Sun shine.

The next generation of solar neutrino experiments such as SNO+ will be able to make precision measurements of different parts of the solar neutrino spectrum. This will further our understanding of the solar fusion mechanisms and ultimately the evolution and fate of the Sun. These measurements will also test in detail the mechanisms for neutrino flavour oscillations.

Geo Neutrinos
Geo-neutrinos is the term used for the electron antineutrinos produced by the decay of radioactive materials in the Earth - in particular uranium and thorium. Geo-neutrinos were first detected by the KamLAND experiment in Japan. The interest in geo-neutrinos is that they are a way to measure the total amount of heat produced in the Earth from radioactivity. Heat from radioactivity is thought to account for between 40% and 100% of the Earth's total (present day) heat flux. There is an interest to measure geo-neutrinos at SNOLAB because it is located in the centre of the North American continental and "sees" a different distribution of geo-neutrinos than what is observed in Japan. The SNO+ experiment will do this using a detector containing 1 million litres of liquid scintillator.

SNOLAB

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