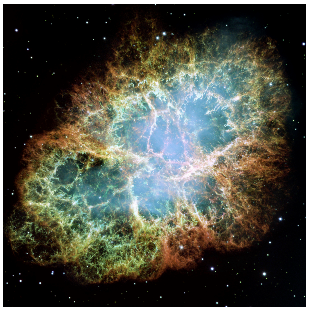
Supernova

Exploding star



The crab nebula is a supernova remnant that is located in our Milky Way galaxy*

A view of the cabled NCD (Neutral Current Detector) Electronics in HALO.

Supernova 1994D*

A supernova is the spectacular explosion of a star that gives off enough energy to outshine everything else in its galaxy for weeks or months before slowly fading from view. Supernovae occur almost every second in the observable universe! In a galaxy the size and age of the Milky Way however, they only occur about once every 25 to 50 years.

What causes a supernova?

A supernova can happen one of two ways; the first is when a white dwarf (which is a very old, dense star) and another star orbit the same point (this is called a binary star system) and the white dwarf collects more and more material from the other star, becoming more and more dense. As this happens, the temperature and pressure in the white dwarf increase until nuclear fusion restarts at its core. Because a white dwarf is so dense, this fusion very quickly spreads out from its core, giving off enough energy to explode the star and cause a supernova.

The second type of supernova happens at the end of a single star's life. As a star ages, it runs out of nuclear fuel and ceases nuclear fusion at its core. This causes some of its mass to collapse into its core. The core eventually becomes so heavy that it cannot combat its own gravitational force (mass causes gravity), and it collapses and explodes, causing a supernova.

Why is studying supernovae important?

Studying supernovae gives physicists insight into how the universe works. Physicists have already determined that when a supernova occurs, elements from the exploding star shoot off and distribute throughout space. These elements can become part of new stars and planets. In fact, some of the elements on Earth have come from supernovae. Studying supernovae has also revealed that we live in a universe that is expanding at an accelerated rate.

Neutrinos and supernovae

Neutrinos are intimately connected to supernovae. When a supernova occurs, it gives off an immense amount of energy and matter. Most of the energy comes from neutrinos. In fact, in type 2 supernovae, only about 1% of the energy is in the form of photons (light particles), while 99% is in the form of neutrinos. Neutrinos, unlike photons and other materials, have very little mass and no charge, and pass through

everything in space, rarely interacting with anything at all. In a supernova explosion, it can take anywhere from tens of minutes to several days for most matter to travel from a star's centre to its surface before shooting out into space. Neutrinos however, reach Earth before any other matter from a supernova can.

Neutrinos and the Supernova Early Warning System (SNEWS)

The neutrino burst signal that emerges promptly from a supernova's core, beats out all other matter and light in reaching Earth. As a result, the detection of the neutrino burst from a supernova can provide an early warning for astronomers. The SNEWS project is an international collaboration of experimenters representing current supernova-neutrino-sensitive detectors. The goal of SNEWS is to provide the astronomical community with a prompt alert of the occurrence of a supernova event within our galaxy or from a near-by star.

The SNEWS network has been running since 2003 and currently has seven neutrino experiments involved: Super-K (Japan), LVD (Italy), Ice Cube (South Pole), KamLAND (Japan), Borexino (Italy) Daya Bay (China), and HALO (Canada).

These supernovae neutrino experiments are based at SNOLAB:

SNO+ is a new experiment using the former SNO detector infrastructure. By replacing the heavy water used in the SNO experiment with liquid scintillator, the detector will be able to study low energy solar neutrinos, geo-neutrinos and reactor neutrinos as well as conduct a supernova search. The SNO+ experiment will also add tellurium into the scintillator to search for neutrinoless double beta decay from the 130Te isotope.

HALO (Helium And Lead Observatory) is used to detect supernovae (collapsing stars) using 3He proportional counters. When a star collapses, an influx of neutrinos is produced and travels outwards. The HALO experiment can observe the neutrino burst from the supernova and alert other laboratories and astronomers in the world that a supernova is occurring before it can be seen from Earth.

*Images courtesy of apod.nasa.gov.