Nobel Prize for Queen's University Physics Professor

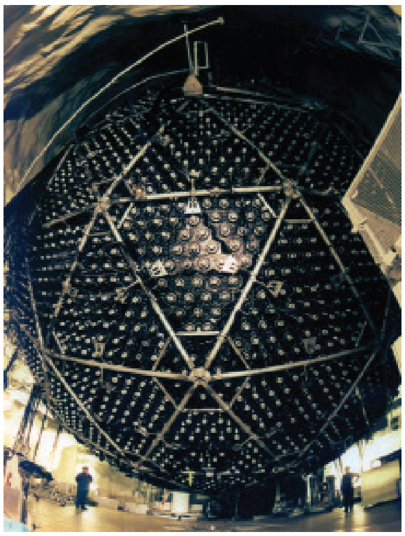
Prof. Arthur McDonald, Queen's University Photo by K. McFarlane

On October 6, 2015, Kingston Ontario, received some very exciting news. A Queen's University physics professor, Arthur B. McDonald, won the Nobel Prize in Physics, alongside Professor Takaaki Kajita of the University of Tokyo, Kashiwa, Japan. The Nobel Prize was awarded to McDonald and Kajita "for the discovery of neutrino oscillations, which shows that neutrinos have mass" (*www.nobelprize.org*). How exciting that we now have a Nobel laureate in our very own city!

But you may be wondering: what are neutrinos?

Neutrinos are fundamental, subatomic particles. Another (perhaps more familiar-sounding) fundamental particle is the electron. Protons, on the other hand, are not fundamental particles. Protons are made up of subatomic particles called quarks, which come in three different types (or "flavours", as physicists like to call them). Neutrinos also come in three different flavours: electron-neutrinos, muon-neutrinos, and tau-neutrinos.

Neutrinos are interesting particles, because they travel incredibly fast and were previously thought to be massless. They are also electrically neutral, and therefore not affected by electromagnetic forces. Because neutrinos are neutral, tiny, and quick, they can travel through most matter unimpeded.



SNO Detector www.sno.phy.queensu.ca/group/projects.html

Different flavours of neutrinos are created in many types of particle interactions. In particular, electron-neutrinos are created by fusion reactions in the core of our Sun. Because neutrinos travel so easily through matter, these electron-neutrinos escape the Sun and fly into space. Some of these particles travel towards the Earth, where we can detect them. Thus, measuring the number of neutrinos passing through the Earth provides observational evidence that may refute or support our theoretical predictions about the Sun's core and how it functions.

In Canada, we have our very own neutrino detector: the Sudbury Neutrino Observatory (SNO). The detector was built over 2000 metres below ground, inside a mine in Sudbury, Ontario, and uses over 1000 tonnes of heavy water. Heavy water reacts with neutrinos to produce Cherenkov radiation, which can then be detected by photomultiplyer tubes. This elaborate set-up is what McDonald and his research team used to detect neutrinos from the Sun.

The Solar Neutrino Problem

People started detecting neutrinos from the Sun in the 1960s, but they quickly noticed a problem – there weren't enough of them. Theoretical physics predicted about three times as many electron-neutrinos than were detected! This became known as the solar neutrino problem, and solving this problem is what earned Arthur McDonald the Nobel Prize in Physics. As it turns out, the electron-neutrinos created in the Sun's core can change flavour to tau- or muon-neutrinos while travelling to Earth. Tau- and muon-neutrinos are much more difficult to detect than electron-neutrinos, so most experiments were only measuring the electron-flavoured ones. The ability to change flavours also shows that neutrinos must have mass.

Congratulations to McDonald and Kajita!