MINOS ready to study mysterious neutrinos

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A new five year research programme studying the properties of mysterious particles called neutrinos is due to start on March 4th 2005. The first neutrinos generated in a new particle accelerator beam for the Main Injector Neutrino Oscillation Search (MINOS) were observed during commissioning work last week at the Fermi National Accelerator Laboratory, Fermilab, near Chicago in the USA. These neutrinos will be sent on a 735 km journey through the earth to a 5,500 ton detector located in a historic iron mine near the Canadian border. This heralds the successful completion of four years of construction and marks the final stage of preparation for the experimental programme for UK physicists, who are working with scientists from the USA, Russia, Greece, France and Brazil.

MINOS will investigate the phenomena of neutrino oscillations and neutrino mass - one of the most important and exciting topics in particle physics today with implications for both the Standard Model used in particle physics and cosmological models of how the Universe formed. The experiment will formally start at a ceremony in Fermilab on March 4th when commissioning is completed. So far, the commissioning is going well - when the neutrino supply was switched on for the first time, scientists thought that it might take weeks before they saw the signal in the first, or 'near detector'. Instead they picked up the first signal after only one and a half hours. Now they are working on the final configuration so that they can detect this beam in the 'far detector' located in the Soudan Mine in Northern Minnesota.

Neutrinos are extremely abundant in nature but interact so weakly with matter that millions pass through the human body unnoticed at any moment. This means that many of their important properties have remained hidden until recent times. Three different types of neutrino are known to exist (the electron, muon and tau 'flavours'). Recent experiments such as SNO (the Sudbury Neutrino Observatory, Canada, involving UK scientists) and Super Kamiokande in Japan, have studied neutrinos from the sun and from cosmic rays striking the Earth and demonstrated that they are capable of transforming (oscillating) from one type to another as they fly through space. This property is of great interest to scientists and also requires that one or more of the neutrinos, previously thought to be mass-less, do have a small mass. It offers exciting possibilities to cosmologists in understanding how the Universe developed and contributes to dark matter - the 'missing mass' of the Universe which can be detected gravitationally but can not be observed directly with conventional telescopes.

Whilst experiments at SNO and elsewhere have provided evidence of neutrino oscillations, they rely on the Sun or cosmic rays as the neutrino source and can only measure neutrinos as they reach the Earth. To make more detailed and controlled measurements, scientists need to create their own neutrino source and measure the neutrinos before and after any oscillation in order to see the effect in detail.

The MINOS experiment will use the new, intense beam of muon-type neutrinos produced at Fermilab to study the properties of these elusive particles. The neutrino beam will be projected straight through the earth from Fermilab (near Chicago) to the Soudan Mine in Northern Minnesota - a distance of 735 kilometres. No tunnel is needed because neutrinos interact so rarely with matter that they can pass straight through the earth virtually unhindered.

Two massive neutrino detectors have been built by MINOS, both of which are complete and ready for the beam. The 1000 ton 'near' detector, placed close to the beam source at Fermilab, will sample the beam as it leaves Fermilab and provide the control measurements. The 5,500 ton 'far' detector, half a mile underground in the Soudan Mine, Minnesota, will measure the neutrinos when they arrive, just 2.5 milliseconds later. The detectors have to be a long distance apart to allow the neutrinos, which travel at close to the speed of light, time to oscillate. "By comparing these two measurements we will be able to study how the neutrinos have oscillated and provide the world's most precise measurement of this effect with muon-type neutrinos" explains the MINOS UK spokesperson, Geoff Pearce of the CCLRC Rutherford Appleton Laboratory. "These measurements are eagerly awaited by the scientific community and will help us to understand the nature of neutrinos and incorporate this new knowledge into the Standard Model of particle physics".

The MINOS experiment involves scientists, engineers, technical specialists and students from 32 institutions in 6 countries. The UK played an important role in the projects' conception and the UK groups have since been at the core of the international collaboration, providing a substantial investment in the design and construction of the detectors as well as preparations for analysis of the data. Commissioning of the new neutrino beam at Fermilab will continue throughout February after which the experiment will begin operations. "This is a very exciting time" says Geoff Pearce, "after all the hard work designing and constructing the experiment we can't wait for the data to start flowing and to learn more about neutrinos".

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