Fermilab experiment to beam neutrinos through Dairyland

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In an effort to pin down the elusive nature and qualities of one of nature's most intriguing subatomic particles - the neutrino - scientists at Fermi National Accelerator Laboratory, or Fermilab, in Illinois will soon send a beam of the ghostlike particles coursing through subterranean Wisconsin to a detector deep in a mine in northern Minnesota. The goal of the $170 million project is to help scientists gain some accurate measurements of a particle that has practically no heft.

"They almost have no mass, no charge, and have the weakest interacting force that we know," says Albert Erwin, a University of Wisconsin-Madison professor of physics and a participant in the massive Fermilab experiment.

Those qualities enable neutrinos, which in nature are produced in the nuclear reactions in the sun and other celestial objects, to course through matter as if it does not exist. Yet, scientists think, neutrinos may account for much of the mass of the universe and may play a role in the origin of neutrons, protons and electrons - the basic building blocks of all atoms in the universe.

The beam generated at Fermilab will bisect Wisconsin from the southeast corner of the state to the very northwest corner, before traveling through Lake Superior toward a steel target set deep in an old iron mine in Soudan, Minn.

"Neutrinos are harmless," says Erwin, the UW-Madison scientist most

closely involved with the experiment, which is known as MINOS - for Main Injector Neutrino Oscillation Search.

The five-year MINOS experiment hopes to unravel the mysteries associated with neutrino origin and mass, and how they change during their 2.5-millisecond trip from Batavia, Ill., to the Soudan Mine.

To produce neutrinos, scientists at Fermilab accelerate protons - the basic components of an atom - around a four-mile ring that ends in a violent collision at a graphite barrier. This miniscule collision produces neutrinos that are channeled through the earth toward a massive steel target set deep in the Soudan Mine.

The neutrino beam, which is directed in a manner similar to a beam of light produced by a flashlight, is aimed downward at a 3.3-degree angle toward the detector, known as the Soudan Underground Laboratory, 450 miles northwest of Batavia.

Although the beam will course through the earth beneath Wisconsin, it will be unnoticeable, little different from the neutrinos that exist in nature and are constantly bombarding the earth.

Neutrinos are phantomlike and pass through all matter, including people, with no effect. This insignificant interaction makes neutrinos an extremely difficult subject of study, says Erwin.

"Neutrinos theoretically exist in three ‘flavors': electron neutrinos, muon neutrinos and the more recently discovered tau neutrinos," Erwin explains. "When neutrinos are produced in the sun and stream through the atmosphere, planets and other celestial objects, they transform back and forth between these three flavors."

The Fermilab experiment emits the neutrinos in their muon form.

Scientists hope the long distance to the Soudan detector will provide enough time for the muon neutrino to transform into the two other flavors, providing a glimpse of the lifestyle of the elusive particle.

The giant detector in Soudan is made out of steel and plastic plates that are placed in the path of the neutrinos from Fermilab. The 6,000-ton steel detector is where scientists hope to sample neutrino flavors when they arrive in Soudan.

Out of trillions of neutrinos produced by the MINOS experiment, only a few thousand will create detectable events at the Soudan Mine. This means that even though muon neutrinos will be released for ten millionths of a second every two minutes, 24 hours a day, seven days a week, for the next five years, only one hour of data will be analyzed.

Nonetheless, Erwin believes the experiment will give scientists new insight into the nature of the sun and other heavenly objects based on the transformation of the fast traveling neutrinos.

Even more tantalizing - and perhaps the most interesting hoped-for result of the MINOS experiment - is the opportunity to uncover the secrets of the dark matter that scientists believe pervades the universe. Dark matter, which may account for approximately 90 percent of all matter, is matter that we know exists, yet does not give off any light, says Erwin.

"We know that dark matter is out there, but we don't know what the missing mass is made of. If this experiment is a success, we might find that some of that missing mass is neutrinos."

UW-Madison scientists are excited about the Fermilab MINOS experiment, Erwin says, because it may bring science one step closer to identifying a particle that helps to keep the universe together.

Source: University of Wisconsin

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