

# Playing catch on tiny scale

By *srlinuxx*

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An hour north of Duluth, Minn., and a half-mile down, the dim tunnels of the Soudan mine open up to a bright, comfortably warm cavern roughly the size of a gymnasium, 45 feet high, 50 feet wide, 270 feet long.

Well hidden from the lakes, pine forests and small towns of northern Minnesota, the mine churned out almost pure iron ore until it closed in 1962. Today, it is a state park, and it houses a \$55 million particle physics experiment that is part of a worldwide effort to unravel the secrets of the neutrino, one of the least known and most common elementary particles.

Because of discoveries over the past decade, the ubiquitous neutrino, once a curiosity in a corner of particle physics, now has the potential to disrupt much of what physicists think they know about the subatomic world. It may hold a key to understanding the creation of hydrogen, helium and other light elements minutes after the Big Bang and to how dying stars explode.

The experiment at Soudan will measure the rate that neutrinos seemingly magically change their types, giving physicists a better idea of the minute mass they carry. An experiment at Fermilab outside Chicago is looking for a particle called a "sterile neutrino" that never interacts with the rest of the universe except through gravity.

Astrophysicists are building neutrino observatories in Antarctica and the Mediterranean, which will provide new views of the cosmos, illuminating the violent happenings at the centers of galaxies, distant bright quasars and elsewhere.

The particle is nothing if not elusive. In 1987, astronomers counted 19 neutrinos from an explosion of a star in the nearby Large Magellanic Cloud, 19 out of the billion trillion trillion trillion trillion neutrinos that flew from the supernova. The observation confirmed the basic understanding that supernovas are set off by the gravitational collapse of stars, but there was not enough information to discern much about the neutrinos.

The much larger detectors in operation today, Super-Kamiokande in Japan, filled with 12.5 million gallons of water, and the Sudbury Neutrino Observatory in Canada, would capture thousands of neutrinos from a similar outburst. Because neutrinos are so aloof, successful experiments must have either a lot of neutrinos, produced en masse by accelerators or nuclear reactors, or a lot of matter for neutrinos to run into. Given the cost of building huge detectors, scientists are now turning to places where nature will cooperate.

In Antarctica, the IceCube project will consist of 80 strings holding 4,800 detectors in the ice, turning a cubic kilometer of ice into a neutrino telescope. Fourteen European laboratories are collaborating on a project called Antares that will similarly turn a section of the Mediterranean off the French Riviera into a neutrino detector.

The Soudan experiment takes the other approach, using bountiful bursts of neutrinos generated by a particle accelerator. Shoehorned into the back of the underground cavern is a detector of modest size, a mere 6,000 tons, consisting of 486 octagonal steel plates and standing upright like a loaf of bread. Each plate, 1 inch thick and 30 feet wide, weighs 12 tons.

On a visit to the cavern last month, William H. Miller, the laboratory manager, pointed at the far rock wall. "Fermilab, that way," he said. This experiment is intended to catch just a few of the neutrinos created

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