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Physicists Detect Signs of Last Building Block of Matter

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Physicists have completed their long quest to find a specimen of every member of the menagerie of subatomic building blocks that make up the material world.

The 12th and last particle to be directly detected is the tau neutrino, one of three types of neutrino--an elusive particle that has little or no mass, no electrical charge, and passes through matter like a ghost. Scientists estimate that some 1,800 neutrinos per cubic inch swarm throughout the cosmos, and 65 million generated by the sun are whizzing through a person's thumb every second.

Today, an international collaboration of 54 scientists at the Department of Energy's Fermi National Accelerator Laboratory (Fermilab) outside Chicago will formally announce that it has detected four instances of the predicted signature of the tau neutrino: a track with a distinctive kink in it, etched in an emulsion.

Researchers took almost three years painstakingly culling the quartet of telltale zigzags from among 6 million potential particle interactions recorded by their 50-foot-long detector.

"We finally have direct evidence that the tau neutrino is one of the building blocks of nature and that it reacts with other particles in accordance with our current scientific theory," said physicist Byron Lundberg, spokesman for the Direct Observation of the Nu Tau (DONUT) experiment conducted by physicists from the United States, Japan, Korea and Greece.

Nobel laureate Leon Lederman called the confirmation "an important and long-awaited result." He and colleagues Jack Steinberger and Melvin Schwartz were awarded the prize in 1988 for the discovery of one of the other two types of neutrino.

Martin Perl of Stanford University, another Nobel recipient for particle work, said, "DONUT was not an easy experiment, and now it opens a whole new world. There is the possibility of the tau neutrino interacting somewhat differently from the other neutrinos. We might have a chance of learning more about all other particles."

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Widely accepted evidence two years ago from the U.S.-Japanese project called Super-Kamiokande (Super-K), along with others, indicated that the neutrino has a slight mass, contrary to leading theory. Because the particle is so ubiquitous, scientists said, a confirmation of its mass could have profound implications.

The results of numerous neutrino experiments underway or planned, including a major one in Europe using the same emulsion technique developed for DONUT, could reverberate throughout scientific understanding of the smallest elements in nature to the fundamental composition of the universe, to scientists' search for a unifying theory of everything and "why we're here," said John G. Learned, a neutrino researcher at the University of Hawaii who participated in the Super-K experiment.

"We've shown that the neutrino mass is probably at least as much as all the visible stars in the sky," he said.

Society's gradual acceptance that all matter is made up of atoms was achieved over considerable resistance, including threats of death against 17th-century advocates of the proposition and at least one suicide by a frustrated physicist.

The term atom to the ancient Greeks meant "uncuttable." But beginning with Ernest Rutherford in 1910, scientists learned to fire subatomic projectiles at targets and study the resulting debris to discover new particles. They showed that even the tiny atom is cuttable--made up of even smaller units dubbed quarks (from a line in James Joyce's "Finnegans Wake") and electrons, bound together by particles called gluons (because they act like glue) and photons (the particles that make up light).

Physicists soon found themselves swamped with hundreds of particles with varying masses, energies and longevity. Like biologists struggling to classify invisible animals, they began to lump the bizarre particle zoo into families. The resulting distillation, known as the Standard Model, postulates that virtually every conceivable state of matter or energy can be embodied in a few particles: The "matter particles" include six kinds of quarks, and six kinds of leptons (from the Greek word for "small"). Other particles carry fundamental forces such as electromagnetism.

The neutrino resides in the lepton clan. Scientists now know it comes in three personalities, each linked to one of three cousins in the clan--the electron (which carries electrical current in household appliances), the muon (like the electron but more massive and therefore less stable) and tau (a dramatically porkier version of the electron), discovered by Perl in 1976.

In nature, the neutrino is born in the radioactive decay processes at play in the sun, or in cosmic rays. Swiss physicist Wolfgang Pauli first proposed the existence of the neutrino in 1931, to account for energy mysteriously missing after a type of radioactive decay. Its existence was confirmed in 1959.

In 1997, scientists used Fermilab's Tevatron accelerator to produce an intense beam of neutrinos presumed to contain the tau (rhymes with "cow") variety. The beam crossed iron plates sandwiched with layers of emulsion. In that bull's-eye, only about one in one million million tau neutrinos hit an iron nucleus to produce its kissing cousin, the tau lepton, creating the distinctive kink in the one-millimeter-long track.

The new emulsion system enabled scientists at Nagoya University in Japan to use special scanning devices to create images of the tracks, which are comparable to the mark light leaves on a photographic film, only in three dimensions.