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U researchers discover elusive atom particle

David Anderson - *Staff Reporter*

An international collaboration of 54 physicists, including eight researchers from the University's School of Physics and Astronomy, found the last piece of a century-old puzzle.

With the first direct evidence of the tau neutrino -- the twelfth and final piece in the Standard Model of physics -- the team brought worldwide attention to the Twin Cities campus.

"It's an experiment that will go into the textbooks," said professor Roger Rusack, who supervised the University's team.

Six graduate students -- John Trammel, Jason Sielaff, Reinhard Schwienhorst, Carolyn Erickson, Judd Wilcox, David Ciampa -- participated in the Direct Observation of the Nu Tau (DONUT) project as their research thesis.

The collaboration announced the results July 21, after more than five years of research completed at the Fermi National Accelerator Laboratory in Batavia, Ill., and on university campuses in the United States, Japan, South Korea and Greece.

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Beginning with Ernest Rutherford in 1910, physicists have shown that atoms (ancient Greek for "uncuttable") can be broken into even smaller units, such as quarks and electrons.

The Standard Model, a classification table for physical matter comparable to the Periodic Table of chemical elements, includes six types of quarks and six types of leptons. The last lepton is the tau neutrino. The elusive particle has no electrical charge and cuts through matter like a ghost.

Hence the difficulty of the experiment.

"DONUT was not an easy experiment, and now it opens a whole new world," said Martin Perl, who first theorized the existence of the tau neutrino in 1978. "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."

Building the experiment and running it took two years.

To create neutrinos, the team had to smash protons onto a block of tungsten at velocities approaching the speed of light.

The tau particles generated by the collision then decay into tau neutrinos and stream through layers of shielding to form neutrino beams. The beams then pass through layers of iron, plastic and film-like emulsion that records their track.

The life span of a tau particle is about one trillionth of a second.

The University team built the shielding that deflected away unwanted secondary beams and the stand for the emulsion sheets that tracked the remaining neutrino beams.

Wilcox and Trammel also wrote software used during the experiment, and Sielaff and Erickson spent two years at the Fermi laboratories running the project and collecting data.

Schwienhorst joined the team in 1997. The students spent the last three years at the University analyzing data under Heller and Rusack's supervision, a process comparable to looking for a needle in a haystack.

Sielaff and Schwienhorst agree the DONUT experiment is more fun now that they have positive results.

"It's been a rush to have an answer," Sielaff said. "It's by no means complete, the experiment is not over. There's a lot more to be done. But it's nice when you can finally say, 'ahhh.'"

The effort was rewarded by large media attention, including a front-page article in the New York Times, following the observation's announcement.

"It was very nice to see students come into it and then realize that what they are doing is of great interest to the world," Rusack said.

Erickson and Sielaff represented the collaboration last month at an American Physical Society meeting in Columbus, Ohio.

The search for the neutrinos has generated four Nobel Prize laureates so far.

Swiss physicist Wolfgang Pauli first proposed the existence of the neutrino in 1931 to account for energy missing after some types of radioactive decay.

Two American physicists, Frederick Reines and Clyde Cowan, were the first to shed light on the enigmatic particles with direct proof of the electron neutrino in 1956. Six years later, Leon Lederman, Jack Steinberg and Melvin Schwartz confirmed the existence of the muon neutrino, the second neutrino.

Perl, now a Stanford University professor, led the way for the DONUT physicists by discovering the tau lepton in 1995.

"Ten years ago, no one thought it would be possible to see the tau neutrino," Rusack said.

Although direct evidence of the tau neutrino is a significant advancement for the world of physics, the July announcement was no stunner.

"It would have been a bigger surprise if we hadn't seen it," Heller said. "Those are the interesting things, when your theories are just wrong. You would like to see something that shows that everybody's wrong."

Nevertheless, proving tau neutrino theories true was a necessary step to increase our knowledge and understanding of the universe.

Whether neutrinos have mass could explain what prevents stars from collapsing from gravitational attraction.

"In my view it closed a chapter in terms of filling all the slots," said Fermilab physicist Byron Lungberg, who initiated the research.

The University team's remaining members continue to meet regularly to discuss probabilities and interpretations of the results.

"You learn that you are more comfortable with the Standard Model, even though there are many things you don't understand," Heller said. "If you are a physicist, you believe anything can be understood. Maybe we don't understand it now, but we believe the universe is rational and it can be explained by a few very simple things."

The physics community now looks ahead to two new developments in high-energy physics research: unveiling the mass of neutrinos and detecting the last unseen particle, the Higgs boson. The research will be a race between Fermilab and the Geneva-based Centre Europaire.

"Physics gives you new ways of looking at your everyday world," Heller said. "It's like art in a sense. It expands ways that you think about things that you see every day."

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