Top scientific breakthrough opens door to understanding universe

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Physicists at Virginia Tech, as part of a collaboration with U.S. and Chinese researchers, took part in one of 2012's top scientific breakthroughs according to *Science* magazine. It's a breakthrough that could have a significant impact on physics and the universe as we understand it.

The team, working at the Daya Bay reactor facility in China, discovered the third and final known neutrino mixing angle. The discovery was heralded by the magazine as one of nine runners-up to the discovery of the Higgs-boson.

"This is a well-deserved recognition for a result that has changed significantly the research in an important area in physics," said College of Science Dean Lay Nam Chang, himself a physicist. "The role Virginia Tech is playing in the Daya Bay collaboration contributed substantially to a robust determination of this last mixing angle."

Among the scientists at Virginia Tech who took part are, Leo Piilonen, department of physics chair, physics professors Patrick Huber and Jon Link, postdoctoral researcher Deb Mohapatra, Joseph Hor of Hong Kong, and Meng Yue of Qiqihar, China, both doctoral students in physics, and lab technician Jo Ellen Morgan.

The recognition in Science magazine, "feels good," according to Link. "Our work is a little esoteric; it's not everyone's cup of tea, but it's nice to be recognized."

And the discovery of the last mixing angle isn't the end of the line for Virginia Tech researchers. In fact, the discovery may have opened exciting new doors in physics.

"The standard model of particle physics, which describes the behavior of all particles from neutrinos to the Higgs boson, is very frustrating," Link said. "The model works so well that for decades everywhere we've looked we've found things to be in agreement with the model. If that keeps up, we'll be done measuring the known parameters in 15 years.

"But in neutrino physics there may be something interesting going on, and Virginia Tech has been at the forefront of studying this for some time," Link said. "There is evidence of a fourth type of neutrino and possibly more. The evidence has shown up in different places and it's always marginal. For example, when we look at neutrinos coming from a nuclear reactor, like Daya Bay, we see about 6 percent fewer than we expect from calculation. This can be interpreted as evidence of additional neutrinos mixing with the three known types."

Ironically, it turns out that when dealing with the tiniest of particles, a door to a potential fourth neutrino is being opened in space, by astronomers looking at much larger objects.

When the universe was formed it was opaque. A seething plasma of charged particles through which even light could not pass unmolested. As the universe cooled electrons and protons paired off, and by around 300,000 years the universe was 'transparent'.

"When astronomers look at the light coming from the earliest moments of the transparent universe, they see ripples of structure which can tell them a lot, including the number of particles involved," Link said.

And what numbers do astronomers count? Well, for starters, they count four neutrinos.

"When they measure the number of neutrino-like particles they're finding that it's more consistent with four than with three. If it holds up, this extra particle may not be a neutrino at all," Link said. "It may be some other unknown light particle. But if it is another neutrino, it's not a part of the standard model and, interestingly, it does not behave like the other three neutrinos. We call it a sterile neutrino, because it's even less engaged in the world around it than normal neutrinos."

The significance of a sterile neutrino could fill in a lot of blanks for scientists involved in questions dealing with the earliest moments of the universe and the nature of matter.

"It could account for many of the different anomalies we see," Link said. "Or it could just be we're not measuring precisely enough – but it's a tantalizing hint."

Link and Huber have been working for some time on the case for the sterile neutrino. In 2011 the pair hosted a conference at Virginia Tech which ended in a motion to write a white paper to investigate the evidence and see if new experiments are needed. Sixty people attended the conference in person and more than 200 contributed to the white paper.

"Virginia Tech is at the vanguard of neutrino research," Link said. "It's an exciting time because there are a number of theories suggesting multiple sterile neutrinos. It's possible that one or more slightly heavier sterile neutrinos could be responsible for [dark matter]."

The matter we're made of, and of all the stuff we see, is only about five percent of the universe. There's another 20 percent of dark matter which was originally postulated to account for the fact that when scientists looked at galaxies they could count the light and see the gasses through radio waves – but it wasn't enough mass in regular matter to account for the speed of rotation of galaxies.

"It turns out there is this dark matter, but we don't know what it is because we've never observed a particle that could explain it," Link explained. "But we assume it's a weakly interacting particle that may be all around us and moving through us. That's frustrating," he admits, "but it's possible that if this mystery particle, the sterile neutrino, exists a heavier version could explain dark matter."

Explaining dark matter: Just the cup of tea for Virginia Tech physicists.

Provided by Virginia Tech

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