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On Beyond Einstein

Alan Kostelecky and the IU Center for Spacetime Symmetries

Did you hear? Reports of something traveling faster than light! Scientists in Europe recently released the results of an experiment in which they clocked sub-atomic particles called neutrinos breaking the sacrosanct speed-of-light barrier.

But wait a minute here. Einstein's assertion that nothing can go faster than the speed of light has been a bedrock principle of physics for more than one hundred years. Doesn't this news threaten to shatter our most fundamental understanding of how the universe works? Well, maybe not. In fact, the news isn't disruptive to the ideas of a group of physicists at IU led by **Alan Kostelecky**, distinguished professor of theoretical physics. Through work beginning more than twenty-five years ago, Kostelecky and his group of students and post-docs have created a theoretical framework for incorporating faster-than-light possibilities into the accepted model used by physicists.

Kostelecky reacted to the neutrino news with a mixture of skepticism and intrigue. "Extraordinary claims require extraordinary proof," he says, "and extraordinary proof in this case requires additional independent experiments able to reproduce the same effect." Until the results are corroborated by the work of other scientists, Kostelecky is reluctant to assume that the experiment has truly established something profoundly new. Experiments of this sort involve a dizzying array of factors that must be controlled to a mind-boggling degree of sensitivity. In short, even though the people conducting the experiment are some of the best in the world, there is any number of things that could have gone wrong and skewed the results.

Nevertheless, Kostelecky is intrigued and excited, because if other experiments should indeed confirm that neutrinos can travel faster than light, he just might have some of the hard data he has long sought to support his theories. "I've spent most of my professional career working on this kind of possibility, so for me, it's

tremendously interesting, and if it's true, it's a vindication of what I've been doing," says Kostelecky.

The focus of Kostelecky's research is spacetime symmetries and in 2010 the College established a center to promote work in this area. The IU Center for Spacetime Symmetries (IUCSS) has brought together IU Bloomington faculty from the physics, astronomy, and history and philosophy of science departments, plus faculty from the physics department at IUPUI. "We have people who are both theorists and experimentalists, which is rare," says Kostelecky. "There are other places in the country, and around the world, that are focused on exploring aspects of fundamental physics, but I don't believe there is any other center in the world that focuses on this particular aspect and does so with the rather unique combination of expertise which we have here at IU Bloomington and IUPUI. It's quite a remarkable group of people."

To get at least a broad overview of the work being done at IUCSS, first recall that physicists have been wrestling with a big problem for decades. Einstein's ideas about gravity don't fully mesh with the quantum theory that describes the behavior of subatomic particles. Something has to give, but what? So far, experiments have not provided the clues needed, and no one has proposed a satisfactory theoretical answer.

Kostelecky and his colleagues have approached the problem with the goal of uncovering experimental hints about the unification of gravity and quantum physics. They started with the accepted theory of fundamental forces and particles — a combination of Einstein's general relativity and what's known as the Standard Mode l— and augmented it to accommodate all possible ways in which tiny deviations from the laws of relativity could appear. Called the Standard-Model Extension (SME), this theory proposes a framework for exceptions to the accepted rules. Think of these exceptions as "violations," and think of spacetime symmetries as some of the accepted rules. IUCSS is seeking experimental proof that these violations are actually occurring, even if at the infinitesimally minute edges of our world.

"Spacetime symmetry is ***the*** key idea underlying Einstein's theory of relativity," Kostelecky says. "Since relativity is at the core of almost every aspect of physics that is now done at the fundamental level, spacetime symmetry lies at the heart of theoretical physics." Many experimental physicists have responded to the ideas proposed in the Standard-Model Extension by devising ever more precise ways to test the theory. If Kostelecky's ideas are on target, experimentalists should eventually be able to find specifically predicted violations of spacetime symmetries, and a perfect example would be discovering that neutrinos can fly around faster than light.

But if neutrinos can move faster than light and the ideas in the SME are correct, don't expect any of your science fiction fantasies to materialize. We won't be any closer to time travel or Star Trek's "warp drive." However, IUCSS may be breaking new ground in the search for a fuller understanding of our physical existence. As Kostelecky says, "IUCSS is trying to explore and understand nature at its most profound level."

Photos: Jocelyn Bowie