Lisa Randall

Physics Professor, Harvard University; Author, 'Knocking on Heaven's Door: How Physics and Scientific Thinking Illuminate the Modern World'

CERN or Einstein? Interpreting the Findings

Posted: 9/25/11 10:55 AM ET

A violation of Einstein's theory -- wow -- physics doesn't get more exciting than that. Or so the science punditry has it. A few days ago the OPERA (The Oscillation Project with Emulsion-tRacking Apparatus) experiment in Italy announced they had measured particles to be traveling faster than the speed of light. The implications of this discovery could be sensational -- if it is actually correct and if the least conservative interpretation of the result -- faster than light travel with consequent time travel possibilities -- turns out to be right.

That's unlikely. As I discuss in my book *Knocking on Heaven's Door: How Physics and Scientific Thinking Illuminate the Universe and the Modern World* -- physics in progress is often messy. It's not always the pristine laws and predictions of those laws that many envision when describing science. Scientific research involves going beyond the well-trodden and well-tested ideas and theories that form the core of scientific knowledge. During the time scientists are working things out, some results will be right and others will be wrong. Over time the right results will emerge.

Going beyond the well-established core of knowledge requires experiments that are often at the limit of technology. It also involves ideas that are internally consistent but that we don't yet know to be realized in the universe. These ideas can be very different from existing scientific theories. But they can be essential in more extreme regimes of distance or precision than were previously possible to observe. Such new theories wouldn't negate the successful predictions from before. Even if more fundamental, they would be necessary only when experiments reach the level of precision at which they could make a difference.

That means that the experiment itself could be wrong because the technology or other aspects of the experiment were not fully understood. Or they could be right in which case existing physical theory is an approximation of a more exact and fundamental theory that underlies it. This particular result could even be consistent with an exotic version of the warped extra-dimensional theory that Raman Sundrum and I developed and that I also explain in my book.

So let's step back and consider what this experiment tells us. It attempted to measure the speed of particles called neutrinos. Neutrinos -- like all other elementary particles -- are defined by their charges. They have the root neutral in their name, and indeed they have zero electric charge so they are impervious to the electromagnetic force. They also don't interact under the strong force -- the powerful force that holds particles called quarks together inside a proton or neutron. But neutrinos do interact -- albeit very weakly. In fact, the force through which they interact is known as the weak force. This is the force responsible for nuclear beta decay, which, for example, permits a neutron to decay into a proton, electron, and a third particle -- the neutrino which without extremely carefully designed experiments leaves no observable signatures of its own (strictly speaking, it is the neutrino's antiparticle known as the antineutrino).

Because they interact only weakly, neutrinos are difficult to detect and measure. But difficult and impossible are not the same thing. Experimenters have found clever ways to detect a tiny fraction of the neutrinos in enormous shielded detection devices. The detectors are huge in order to provide more opportunities for neutrinos to interact in order to compensate for the weakness of the interaction. And they are shielded (and buried deep underground) so cosmic rays won't confuse the neutrinos signal they wish to measure.

Physicists are interested in measuring neutrino properties because they tell us about the structure of the Standard Model, the well-tested theory that describes matter's most basic elements and interactions. They measure neutrino masses, as well as a very interesting property of neutrinos known as neutrino oscillation -- the fact that neutrinos can oscillate back and forth into each other -- that is one type of neutrino can get transmuted into another type as they travel along through space or matter.

Physicists want to measure how often this happens and they therefore have set up experiments in which neutrinos of one type get produced in one location and neutrinos of another type are detected elsewhere. How far away they put the detector depends on how big a distance is needed for an oscillation to occur.

Which brings us back to the OPERA experiment. Neutrinos are produced at CERN, the particle physics facility near Geneva that also houses the Large Hadron Collider. And they are detected in a big device located in the Gran Sasso cavern in central Italy, 730 km southeast from CERN. The experimenters make detailed measurements of everything they can, including the distance between the experiments and how long it takes for neutrinos to traverse this distance, which in principle tells about the neutrino mass. The measurements are very challenging and the experimenters are to be applauded for taking on this daunting task.

But the experimenters measured something much more surprising than the value of the neutrino mass. They found their neutrinos traveled faster than the speed of light in a vacuum. They measured distance and they measured time and divided one by the other and found a speed that is bigger than Einstein's theory suggests. The question is what does it mean?

Most likely it means the experimenters made a mistake. Most physicists like myself won't believe the result until every possible caveat has been investigated and/or the result is confirmed elsewhere. It's just too big a result to take lightly. And the experiment requires measuring distance and timing at the level of one part in one hundred thousand. It's especially difficult because it's hard to match the emitted and detected neutrinos. Statistical methods are required. It's tough.

But what about the unlikely possibility that the experimental result is correct? What would that mean? Travel at faster than the speed of light certainly can have dramatic implications that are difficult to understand, such as time travel. But the more conservative possibility is that Einstein is not entirely wrong. Returning to one of the themes in my book, it is that the assumptions on which he built his theory were only approximate and break down at some point.

One example is the symmetry on which the theory is based, which says that the laws of physics are equivalent not only in any direction of space but also for any fixed velocity -- that is physics done with constant speed works the same as physics when everything is at rest. But although so far no one has observed any evidence for it, in principle that symmetry can be violated. And when that happens particles might possibly travel at speeds greater than that of light. Physicists have hypothesized several sources of such symmetry-violation but one of the most interesting might occur if there is an extra dimension of space -- that is one dimension beyond the three (up-down, left-right, forward-backward) that we experience in our daily lives.

I talk a lot about why we might have such an extra dimension and why we wouldn't see it directly even if it exists in my older book *Warped Passages* and my newer one *Knocking on Heaven's Door*, which covers both the physics itself and the scientific underpinnings of the way scientists think. The reason the model Raman and I developed is relevant to the neutrino measurement is that it's a lot simpler to violate symmetries in a way that is compatible with all other measurement if there's an extra dimension. In fact physicists have constructed just such a model of spacetime that obeys all the known physical laws. So if faster than light travel happens, it could be very exciting for Raman and me.

Even so, exciting as it sounds, we're not too optimistic our theory will be discovered this way. This neutrino result has just too many ways to go wrong and even requires special assumptions to be compatible with other preexisting measurements about neutrinos.

Fortunately there are other ways to test our hypothesis. That's what the LHC will do and it's one of many things I hope I convey in my new book *Knocking on Heaven's Door*. Understanding physics and especially the true nature of science can enrich all of our lives and encourage better understanding of issues in today's world as well.

More in Technology...

Homeland Security May Up Social Media Intelligence...

Samsung Galaxy S II Skyrocket Announced For...

Unthink, The 'Anti-Facebook,' Wants To Free You...

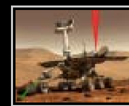
Saving iPhone Battery Life: 10 Tips And...

Why Google Should (And Shouldn't) Offer Gmail App For iPhone

HOT ON FACEBOOK 1 of 3

Unthink, The 'Anti-Facebook,' Wants To Free You From Social Networking 'Dictatorship'

Like 1K



WATCH: NASA Developing Real-Life Tractor Beam

Like 120

HOT ON TWITTER POWERED BY TOPSY

1 of 2

http://t.co/f3eEzN7F

http://t.co/lJcbOV8h

@BlackCanseco

http://t.co/aVpuZciZ

HUFFPOST'S BIG NEWS PAGES

Video | The Kardashians | Greatest Person Of The Day

Redistricting | Joe Biden | Barack Obama

Healthy Living Health News | Reality TV | Elections 2012

MORE BIG NEWS PAGES

SEARCH

FRONT PAGE | POLITICS | BUSINESS | ENTERTAINMENT | TECH | MEDIA | LIFE & STYLE | CULTURE | COMEDY | HEALTHY LIVING | WOMEN | LOCAL | MORE

TECHNOLOGY ENGADGET TECHCRUNCH JOYSTIQ SOCIAL MEDIA APPLE BLOG TRANSLOGIC CRUNCHBASE WOMEN IN TECH

Advertise | Make HuffPost your Home Page | RSS | Careers | FAQ

User Agreement | Privacy | Comment Policy | About Us | About Our Ads | Contact Us