DEVIL PHYSICS

BADDEST CLASS ON CAMPUS

SUPPLEMENTAL READING ACTIVITY

FASTER THAN THE SPEED OF LIGHT

1. This supplemental reading activity is being assigned because it is a great illustration of everything we talked about in chapter one and what we will be talking about in chapter 2:
   a. How theories can evolve over time or even be refuted.
   b. The need to take multiple measurements to ensure the data supports your conclusion
   c. The need to have results of experiments replicated and validated by other scientists
   d. Awareness of orders of magnitude as it applies to extremely small numbers (here, time) and extremely large numbers (here, speed)
   e. Ability to retrieve information from tables in your textbook
   f. Use of conversion factors
   g. Manipulating metric prefixes
   h. Use of scientific notation
   i. Calculating average velocity
   j. Affirms once again that physics is really the coolest branch of science
2. Read the following article and answer the questions that immediately follow it. Don't get wrapped up in the technical aspects of the article, but focus more on the bigger picture.
3. Read the second article and answer the questions that follow it.
4. You do not have to submit these instructions or the two articles with your answers – I already have copies of them Print the two pages with the questions and answers and turn them in or turn them in electronically using the filename format, "LastnameFirstinitialPerXAsgnmntname".
5. **Due Date: 9/25**

Scientific breakthrough: Physicists at CERN have recorded particles moving faster than light

By Robert T. Gonzalez

9/22/11

Published online by io9 at http://io9.com/5842947/scientific-breakthrough-physicists-at-cern-have-recorded-particles-moving-faster-than-light

An international team of scientists at CERN has just announced that they've recorded neutrino particles traveling faster than the speed of light.

According to Reuters:

Antonio Ereditato, who works at the CERN particle physics center on the Franco-Swiss border, told Reuters that measurements over three years showed the neutrinos moving 60 nanoseconds quicker than light over a distance of 730 km between Geneva and Gran Sasso, Italy.

"We have high confidence in our results. But we need other colleagues to do their tests and confirm them," he said.

If confirmed, the discovery would overturn a key part of Albert Einstein's 1905 theory of special relativity, which says that nothing in the universe can travel faster than light.

io9 spoke with James Gillies — head of communications and spokesman for CERN — about the team's results.

"It's important to make clear is that nobody is claiming a discovery, or any contradiction with relativity," explained Gillies. "The OPERA experiment has a measurement they can't account for, so they're opening it up for further scrutiny, and hopefully an independent measurement from another lab."

The OPERA experiment that Gillies is referring to is designed to investigate the phenomenon of neutrino oscillations, wherein elementary particles known as leptons spontaneously transmutate (or shift) from one flavor of subatomic particle (called muon-neutrinos) into another (so-called tau-neutrinos). (You can read all about leptons, muon-neutrinos, and tau-neutrinos in our Ultimate Field Guide to Subatomic Particles.)

CERN provides the OPERA experiment with an energetic beam of pure muon-neutrinos. This beam travels a distance of 732 km to an underground lab in Gran Sasso, Italy, where scientists observe how many of the original muon-neutrinos have transmutated into oscillated tau-neutrinos. Shown here is the OPERA detector located in the Gran Sasso underground labs.

All told, the neutrinos take just 3 milliseconds to make the trip from Geneva to Gran Sasso. But in the course of performing their experiments, Ereditato and his colleagues noticed that the neutrinos were consistently

arriving in Gran Sasso 60 billionths of a second ahead of schedule, i.e. 60 nanoseconds faster than light would over the same distance.

According to the BBC, Ereditato has referred to his team's findings as "an apparently unbelievable result," but after 15,000 measurements the researchers' findings look surprisingly sound.

"My dream would be that another, independent experiment finds the same thing — then I would be relieved," said Ereditato. "We are not claiming things, we want just to be helped by the community in understanding our crazy result — because it is crazy."

"And of course," continues Ereditato, "the consequences can be very serious."

The team has opted to make their results available online, allowing other physicists to more closely inspect and verify their results, and will hold a seminar at CERN tomorrow to discuss their findings. The seminar will be broadcast live at webcast.cern.ch starting at 16:00 CEST.

Want to know more about what neutrinos are? Read io9's Field Guide to Subatomic Particles.

Could this possibly lead to faster-than-light travel? io9's resident physicist, Dave Goldberg, explains why that's not likely. (Sorry!)

[Via Reuters, BBC, and OPERAWeb]

Top image via Ilias Strachinis/Shutterstock

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AP PHYSICS
Name: _____
Period: _____ Date: _____

SUPPLEMENTAL READING ACTIVITY
FASTER THAN THE SPEED OF LIGHT
Questions – Part 1

1. How long have the scientists at CERN been studying this phenomenon? _____
2. How many measurements have they recorded? _____
3. Was that enough to make them satisfied with their results or do they still want outside confirmation or replication? _____
4. For the calculations below, show all of your work, do not round to significant figures, write all of your answers in scientific notation, and display all of the figures your calculator can display.

$$(rate)(time) = (dist) \qquad (time) = \frac{(dist)}{(rate)} \qquad (rate) = \frac{(dist)}{(time)}$$

   a. Using the **current best value** for the speed of light in a vacuum in your textbook, calculate how long would it take for light to travel the 732 km from Geneva to Gran Sasso in seconds.

   _____

   b. If the neutrino takes 60 nanoseconds less to travel that distance, what is it's time of travel?

   _____

   c. Compute the average speed of the neutrino using as many significant figures as your calculator will give you.

   _____

   d. What is the difference between the average speed of the neutrino and the current best value of the speed of light in a vacuum as given in your textbook?

   _____

5. If confirmed, this discovery would overturn what key part of what important theory?

   _____

   _____

6. Where would you go to find more information about leptons, muon-neutrinos, and tau-neutrinos?

   _____

7. Which of the Related Stories would you be most interested in reading?

   _____

ScienceInsider
Breaking news and analysis from the world of science policy

Once Again, Physicists Debunk Faster-Than-Light Neutrinos

by Adrian Cho on 8 June 2012, 3:39 PM |
http://news.sciencemag.org/scienceinsider/2012/06/once-again-physicists-debunk.html

Enough already. Five different teams of physicists have now independently verified that elusive subatomic particles called neutrinos do *not* travel faster than light. New results, announced today in Japan, contradict those announced last September by a 170-member crew working with the OPERA particle detector in Italy's subterranean Gran Sasso National Laboratory. The OPERA team made headlines after they suggested neutrinos traveled 0.002% faster than light, thus violating Einstein's theory of special relativity. The OPERA results were debunked months ago, however. So instead of the nail in the coffin of faster-than-light neutrinos, the new suite of results is more like the sod planted atop their grave.

The OPERA team had timed neutrinos fired through Earth from the European particle physics laboratory, CERN, near Geneva, Switzerland, and found that they made the 730-kilometer trip to Gran Sasso 60 nanosecond faster than they would traveling at light speed. But in February, the OPERA team also discovered that a loose fiber optic cable had introduced a delay in their timing system that explained the effect. A month later, researchers working with the ICARUS particle detector, also housed in Gran Sasso, measured the speed of neutrinos fired from CERN and found that they travel at light speed, as predicted. By that point, most physicists deemed faster-than-light neutrinos really most sincerely dead. Some OPERA team members thought the whole episode had besmirched the collaboration's reputation, and in March, two of the team's elected leaders lost a vote of no confidence and tendered their resignations.

Nevertheless, researchers kept at their efforts to test the result. Gran Sasso houses four particle detectors capable of timing neutrinos fired from CERN: OPERA, ICARUS, BOREXINO, and LVD. All four have now found that the neutrino's speed is consistent with the speed of light, as Sergio Bertolucci, research director at CERN, reported at the 25th International Conference on Neutrino Physics and Astrophysics in Kyoto, Japan. The speed of neutrinos was also measured by researchers working with the MINOS experiment, which shoots neutrinos 735 kilometers from Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois, to a detector in the Soudan mine in northern Minnesota. The MINOS team has also found that neutrinos travel at light speed, as Fermilab's Phil Adamson reported at the meeting.

So the chorus has sung and the final curtain has fallen on the faster-than-light neutrino saga. "The story captured the public imagination, and has given people the opportunity to see the scientific method in action—an unexpected result was put up for scrutiny, thoroughly investigated and resolved in part thanks to collaboration between normally competing experiments," Bertolucci says in a CERN press release. "That's how science moves forward." Fair enough. But can we move on now?

Related on Insider

AUGUST 29, 2012

Fermilab Physicists Present Their Reworked Plans for Giant Neutrino Experiment

SUPPLEMENTAL READING ACTIVITY
FASTER THAN THE SPEED OF LIGHT
Questions – Part 2

1. How many different teams of physicists have thus far verified that elusive subatomic particles called neutrinos do *not* travel faster than light? _____
2. Were the teams working collaboratively? _____
3. How many people were working on the OPERA team that made the original discovery? _____
4. What induced the error in timing on the OPERA particle detector? _____

   _____
5. An ICARUS team later detected the OPERA error, but then attempted the same experiment on how many different particle detectors? Name all the particle detectors at Gran Sasso. _____

   _____
6. What was the OPERA team's biggest mistake in announcing their discovery to the world? _____

   _____
7. What United States organization confirmed that neutrinos travel at the speed of light? _____

   _____
8. This incident illustrates the important need for what step of the scientific process? _____

   _____