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Physics in the news

Are neutrinos faster than light?

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The recent announcement that neutrinos produced at CERN arrived at the Gran Sasso laboratory in Italy at a speed faster than light (www.tinyurl.com/3tzreq6**)** has started a lot of physicists talking and raised a considerable number of eyebrows. If the experiment was accurate, it would mean that Einstein's theory of relativity needs a bit of adjustment or, worse, to be abandoned altogether. Put simply, the theory does not allow anything to travel faster than light, so what is happening?

All scientists that I've talked to agree that something must be upsetting the experiment and nobody seems to think that the blame lies with Einstein's theory. It is the cornerstone of modern physics after all. However, the physicists at CERN and Gran Sasso are clever people and they know what they're doing, so I'm in no position to tell them where they've gone wrong. This does not mean that there is nothing to say. On the contrary, I feel that some comment may be enlightening.

Timing neutrinos from CERN

The experiment is easy to describe. The distance between CERN and Gran Sasso is measured accurately and the time it takes the neutrinos to make the journey is determined. Dividing distance by time gives speed. The trouble is, the neutrinos were timed over the 730 km distance at 60 nanoseconds less than it would have taken a pulse of light. This is the result of a huge number of trials over a period of 2 or 3 years. The distance was measured to a precision of about 0.2 metres, but in 60 nanoseconds light can travel 18 metres. It is unlikely, therefore, that the error lies in the distance.

The tricky bit is to get the timing accurate. Clocks have to be synchronised at the two laboratories, but this creates a number of difficulties when you have to get this right to within a few nanoseconds. There are delays in the electronic equipment that does the timing and these all have to be measured and taken into account.

Einstein's general theory of relativity is a theory of gravity. It predicts that time passes at different speeds in different gravitational fields. The difference in altitude between the two labs is about 700 metres, so time passes more slowly at CERN (the lower lab with a higher gravitational field) than it does at Gran Sasso. In addition to that, the straight-line path between the labs (where the neutrinos travel) goes more than 10 km underground at its deepest point. The gravitational field therefore varies along the path, making time pass at different rates as a consequence. You can see from this that timing is a nightmare and I really wouldn't like the job of trying to get it exactly right.

Relativistic effects?

I suspect that the corrections to the measured time due to general relativity effects will be very small, but I've read the original research paper and general relativity is never mentioned. Have they ignored it completely, or done the calculations and found the corrections negligible without telling anybody?

Over the last 100 years, there has never been the slightest hint that there is anything wrong with relativity. The theory has been confirmed many times over to the highest precision. Two factors demonstrate this:

- First, GPS depends on both special and general relativity to obtain nanosecond timing and there is no question about its accuracy.
- Second, in 1987 a supernova was detected from a star 170 000 light years away. The neutrinos and the light arrived within 3 hours of each other. If there had been the same difference in speed as measured in the CERN experiment, there would have been a time difference of about 4 years.

What next?

We need to perform the definitive experiment of boring a straight tunnel between CERN and Gran Sasso so that both neutrinos and light can travel along it and let them have a race. Unfortunately, that is well beyond our current capabilities.

Find out more

PHYSICS REVIEW articles

'Faster than light', Vol. 19, No. 3, pp. 10–13.

'Nobel neutrinos', Vol. 12, No. 4, pp. 18–20

How science works

http://www.quantumdiaries.org/2011/09/23/elementary-my-dear-neutrino/

CERN press release

http://public.web.cern.ch/press/pressreleases/Releases2011/PR19.11E.html