Neutrinos faster than light?—will relativity need revising?

Jonathan Sarfati

Media headlines were recently filled with reports that neutrinos have been clocked travelling faster than light, and even more with claims like "Einstein's theory busted by new discovery".[1] Researchers at CERN (Switzerland) generated neutrinos (see box), ghostly neutral particles, and shot them through the earth to the Gran Sasso National Laboratory (LNGS) in Italy, travelling a straight line distance of 732 km. This was the CERN neutrinos to Gran Sasso (CNGS) experiment. Its aim was to observe neutrino 'oscillations' between the three varieties of 'flavours' (see box). In particular, this experiment generated the type called 'muon-neutrinos', and hoped to observe them changing into 'tau-neutrinos'.[2]

But what they observed was totally unexpected: the neutrinos apparently arrived at the detectors 60 nanoseconds faster than light.[3,4] This implied that they travelled 0.0025% faster than light, or one part in 40,000.[5] This is not supposed to be possible under Einsteinian relativity. Brian Cox, TV presenter and physicist, said:

> "If it is confirmed it will be the most important discovery in physics in at least the past 100 years. It is a very big deal, it requires a complete rewriting of our understanding of the universe … it is such an extraordinary claim that it is difficult to believe."[6]

This seems like too small a difference, but it was larger than their experimental uncertainties. The researchers seemed to be very careful with their analysis. One Ph.D. physicist in Australia, John Costella, had thought their *statistical* analysis was wrong, but then retracted and commended the statistical analysis.[7]

But Costella urged some caution:

> "… the OPERA result—*if its estimates for systematic errors withstand scrutiny, and if it is subsequently confirmed in future experiments*—would arguably be the most important discovery in physics in almost a century [emphasis added]."

The CNGS researchers themselves were likewise commendably cautious:

> "Despite the large significance of the measurement reported here and the stability of the analysis, the potential great impact of the results motivates the continuation of our studies in order to investigate possible still unknown systematic effects that could explain the observed anomaly. We deliberately do not attempt any theoretical or phenomenological interpretation of the results."

Paradigm power

We see here an example of what the physicist and philosopher of science Thomas Kuhn discussed in his famous book *The Structure of Scientific Revolutions*:[8] that normal science is usually conducted within a framework of assumptions or a *paradigm*. In this case, the paradigm is Einsteinian Special and General Theories of Relativity.

Real scientists don't tend towards a naïve falsificationism as proposed by Popper, and they don't immediately jettison a theory because of one anomalous result. This is actually a *healthy* dogmatism: while no theory of science is infallible, by the same token, no single experiment is either. One report cited several skeptical scientists:

> "'That's possible, but it's far more likely that there is an error in the data. If the CERN experiment proves to be correct and neutrinos have broken the speed of light, I will eat my boxer shorts on live TV,' Prof Jim Al-Khalili, professor of Physics at Surrey University said according to The Telegraph.
>
> "Also, Prof Stephen Hawking, the world's best-known physicist,[9] expressed doubts, saying: 'It is premature to comment on this. Further experiments and clarifications are needed.'"[7]

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Figure 1. CERN Control Center

The theories of relativity have passed all experimental tests and predicted very important results, so it would be unreasonable to abandon it on the say-so of one experiment.

Furthermore, previous measurements of neutrino speed suggest that neutrinos travel very close to the speed of light. For example, when supernova SN 1987A was observed, the neutrino speed was observed to agree to one part in 450 million.[10] Even the small difference was attributed to matter impeding light while the ghostly neutrinos barely interacted with the matter. If the neutrinos had really been travelling as fast as the experiment showed, under the usual assumption (which is known to be questionable[11]) that a light-year of distance requires a light-year of travel, they would have arrived over four years earlier.[12] However, the CNGS experiment generated neutrinos with about a thousand times the energy of the supernova neutrinos.[13] Why only those neutrinos above a certain energy should be faster than light is a puzzle. But some theorists have invoked a hypothetical neutrino condensate that would enable certain neutrinos to have an effective velocity above c.[14] Then again, other theorists have argued against superluminal neutrinos:

> "In a terse, peremptory-sounding paper posted online on September 29, Andrew Cohen and Sheldon Glashow of Boston University calculate that any neutrinos traveling faster than light would radiate energy away, leaving a wake of slower particles analogous to the sonic boom of a supersonic fighter jet. Their findings cast doubt on the veracity of measurements recently announced at CERN that clocked neutrinos going a sliver faster than light."[15]

And on 14 October 14, a *Technology Review* (MIT) article claimed that not only did this experiment *not* disprove relativity, but that the apparent contradiction is *solved* by relativity.[16] Ronald van Elburg, from the University of Groningen, argued that the CERN experimenters overlooked the Lorentz contraction because of the motion of the GPS clocks relative to the earth. He calculates that it should cause the neutrinos to arrive 32 nanoseconds early, but then this would apply at both ends of the path. So the total correction is 64 nanoseconds, which is very close to the time difference in the OPERA experiment.

Photo courtesy of Flickr: Adam Nieman

Figure 2. Globe of Science and Innovation at CERN

Would it disprove relativity?

Assuming that the experiment is confirmed and shown to be a real occurrence, what would it mean? Well, not as much as many people think. Actually, relativity prohibits particles from *accelerating past* the light barrier, because the energy required would be infinite. But there are theories of faster-than-light particles, called *tachyons* (from Greek: ταχύς *tachys* = fast), that would be *created* in their faster-than-light state. Thus they are immune from this objection. Furthermore, it is impossible for tachyons to cross the light barrier from the other side, so that part of relativity is safe: this barrier stands. The objection to tachyons is rather that they would travel backwards in time, so they would possibly allow signals to be sent to the past. This would violate the principle of causality. But then, as Dr Costella explained in another paper, antiparticles are well known, and one formulation is that they are ordinary particles travelling back in time.[17]

But more mundanely, let's remember what happened with Newton's laws when they met relativity and quantum mechanics. They remain extremely useful for most purposes, so are still heavily invoked. But at high speeds and high gravity, we must use relativistic equations instead, and for very low masses, quantum mechanics is required. Further, the equations of relativity must collapse to correspond with Newtonian ones at ordinary speeds—after all, they clearly work very well. Similarly, quantum mechanical equations must approach those of classical physics at ordinary masses (many times that of atoms).

What are neutrinos?

This was a particle first proposed by Wolfgang Pauli in 1930, to explain why beta decay seemed to violate physical laws. That is, when a neutron decayed into a proton and electron (beta particle), the decay seemed to violate the laws of conservation of momentum, angular momentum and energy. Pauli's solution was proposing a tiny neutral particle that Enrico Fermi later named the 'neutrino', and this carried off the observed differences in these quantities.

However, these neutrinos proved most elusive. Because they interact only with the short-range 'weak nuclear force', ordinary matter is almost transparent to them. It wasn't until 1956 that a neutrino was detected by a similar reaction in reverse: a neutrino (extremely rarely) reacting with a proton, producing a neutron and a positron. And it wasn't until another four decades that this work was rewarded with the 1995 Nobel Prize for Physics.

Actually, later standard models of particle physics say that the above particles were *anti-neutrinos*, because of the Law of Conservation of Lepton number, a lepton meaning a small particle.[24] Both electrons and neutrinos have lepton number +1, while antimatter equivalents positron (antielectron) and antineutron have a lepton number of –1. So when an electron is generated (+1), as in beta decay and nuclear fission, an antineutrino must be produced (–1); while positive beta decay and nuclear fusion produce positrons (–1), thereby also emitting neutrinos (+1), so that the overall lepton number (0) is unchanged. Or in the detection reaction, an anti-neutrino (–1) plus proton makes neutron plus positron (–1).

Then other leptons besides electrons were discovered: the mu particle (muon μ) and tau particle (tauon τ)—heavier and very unstable versions of the electron. It turned out that they had their own antineutrino counterparts as well.

For a long time, standard models of particle physics argued that the neutrinos had precisely zero rest mass, so should travel at precisely the speed of light, c. This raised a problem for theories of the sun's energy output: if nuclear fusion were the only source of power, then it was producing only a third of the number of neutrinos—the 'Solar Neutrino Problem'. But it seemed to be solved by evidence that neutrinos can 'oscillate' between the three 'flavours': electron-neutrino, muon-neutrino and tau-neutrino.[25] But this required that neutrinos have some mass, contrary to standard models. The most recent estimates of the combined mass of the three varieties is less than 0.28 eV (electron volts).[26] To put this into perspective, an electron is two million times heavier with 0.511 MeV, while a proton is 1836 times more massive still at 938 MeV.

The experiment concerned was actually designed to observe neutrino oscillation. It generated beams of muon-neutrinos that were sent through the earth, hoping that some would change into tau-neutrinos, which would then interact with a neutron and produce a proton plus tauon. This tauon would give a distinctive signal.

Likewise, it is most likely that relativity equations will still prove useful, even if we must refine them where neutrinos are concerned, maybe due to some yet-to-be discovered physics. Similarly, the previous refinement of relativity by Moshe Carmeli for galactic distances[18] leaves most applications in normal distances untouched.

Application for creationists?

There are a few things to learn from this. One of them does *not* seem to be a solution to the distant starlight problem: the tiny difference for high-energy neutrinos does not really help; fortunately there are other ideas.[10] However, when some 1970s creationist scientists proposed that light travelled much faster than today, they were attacked for their alleged ignorance that nothing could go faster than light at its current speed.[19] Now plenty of scientists have no problem in theory with tachyons, and some have proposed that light was much faster in the past to rescue the big bang from its horizon problem.[20,21]

A more important thing to learn is the *grip of the paradigm*: creationist arguments are often ruled out of court because they contradict the ruling paradigm of evolutionary materialism. But a major difference is that scientists are free to criticize relativity, and healthy debate is regarded as healthy even by those scientists who disagree with the CNGS paper. Conversely, dissenters against evolution are routinely fired or have their grades reduced. This was documented in the movie *Expelled*, and in Dr Jerry Bergman's book *Slaughter of the Dissidents*.[22]

The reason for this difference: relativity makes no ethical demands of its followers, but if creation is true, that might imply that we are accountable to our Creator! This is what evolutionists don't want. Philosopher Thomas Nagel is more honest than most:

> "I want atheism to be true and am made uneasy by the fact that some of the most intelligent and well informed people I know are religious believers. It isn't just that I don't believe in God and naturally, hope there is no God! I don't want there to be a God; I don't want the universe to be like that."[23]

In conclusion, this result is fascinating science, but little to do with creation science *per se,* except to illustrate how scientists really work, regardless of arcane definitions of 'science'.

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Does biological advantage imply biological origin?

Shaun Doyle

The origins of sexual dimorphism and multicellularity are two of the greatest mysteries to evolution. For either of them to evolve either requires massive restructuring of the biological system from the molecular to the organismal levels. Moreover, there are massive selection and energetic barriers that must be crossed to get from unicellular to multicellular life and to evolve sexual dimorphism. Two recent news articles have claimed that certain biological advantages in sexual dimorphism[1] and multicellularity[2] provide a reason why they evolved in the first place.

Intra-cell communication and sexual dimorphism

The first study discusses the question: why are there two sexes?[3] In terms of evolution, it's not the best number of mating types because it only allows us to mate with half of the population. However, researchers have proposed that inheriting mitochondrial DNA (mtDNA) from just one parent instead of both may serve to offset this disadvantage. Most sexually reproducing creatures only receive nuclear DNA from their father but get the other half of their nuclear DNA plus their entire cellular structure, including mtDNA, from their mother. The researchers proposed that because this setup only passed one set of mtDNA to offspring, it allowed for more efficient 'synchronization' between the nucleus and mitochondria, and between mitochondria, than would be possible if mitochondria were inherited from both parents. According to their modelling, they were correct—uniparental inheritance of mitochondria (UIM) produced fitter offspring than biparental inheritance