

When 60 nanoseconds threaten modern physics

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AP In this 2005 photo provided by CERN, the European Organization for Nuclear Research, technicians check the magnets.

That the neutrinos travelled 60 billionths of a second faster than light has been reconfirmed

If extraordinary claims require extraordinary evidences, as Carl Sagan's dictum goes, then scientists involved in an experiment called OPERA (Oscillation Project with Emulsion-tRacking Apparatus) have provided just that. By successfully replicating the results obtained on September 22 this year, particle physicists have once again proved that neutrinos travel faster than light.

The latest confirmation brings them one step closer to shaking the very foundation of modern physics — Albert Einstein's 1905 Special theory of Relativity that states nothing can travel faster than light.

If the results announced two months ago shocked and stunned scientists all over the world, a sense of disbelief has set in after the team of scientists reconfirmed the results last Friday.

The experiment involved generating proton pulses and measuring the time taken for the neutrinos to travel 730 km from CERN, Europe's particle physics lab near Geneva to Gran Sasso National laboratory near L'Aquila, Italy. The 730 km distance between the two points has been measured with an error margin of just 20 cm.

A beam of light would take just 2.4 milliseconds to cover this distance. But in March 2011 scientists were shocked to discover that neutrinos travelled 60 nanoseconds (or 60 billionths of a second) faster than light.

This means that neutrinos were travelling at a speed of 299,798,454 metres per second, while the speed of light in a vacuum is slower at 299,792,458 metres per second.

It was not an isolated observation. In fact, scientists found more than 15,000 neutrinos arriving earlier than expected at the Gran Sasso Laboratory. They checked the accuracy of the data for six months before going public. Since the error margin was only 10 nanoseconds, neutrinos were indeed travelling faster than light.

But there was one factor that the team had overlooked. The proton pulses used for generating the neutrinos were of 10.5 microseconds duration and hence relatively longer. There was a possible room for error as it was difficult to tell whether the speed of individual neutrinos was compared with protons arriving at the beginning or end of the 10.5 microsecond-long pulse.

Hence the OPERA team repeated the experiment by reducing the duration of the pulse from 10.5 microseconds to just 3 nanoseconds — a 3,000-times reduction in pulse duration.

Results from 20 events produced from 3 nanosecond pulses showed that the neutrinos still arrived 60 nanoseconds earlier than light. This was the result that was announced a few days ago.

Other possible errors

There is one more possible error factor that has been raised — synchronising to within nanosecond accuracy the two clocks at both locations (in Geneva and L'Aquila, Italy) to time the neutrino's speed. The OPERA team had synchronised the clocks using GPS signals from a single satellite. The use of GPS in high-energy particle physics to synchronise the clocks at either end of the beam path may be one controversial issue as it has never been tried before.

According to an article in *Nature*, Carlo Contaldi of the Imperial College London has challenged the OPERA results as it has not taken into account one important aspect of the general theory of relativity — the difference in the force of gravity at the two locations affecting the rate at which the clocks tick.

Effect of gravity

Compared with Gran Sasso, the CERN site is further away from the centre of the earth and hence would experience slightly stronger gravitational pull. This would result in the clock at CERN running slightly slower than the one at Gran Sasso.

Dario Autiero of the Institute of Nuclear Physics in Lyons, France and physics co-ordinator for OPERA was quoted as saying in *Nature* that “Contaldi's challenge is a result of misunderstanding of how clocks were synchronised.” The team is expected to soon explain the way the clocks were synchronised.

According to *Nature*, one more element that is generating more scrutiny is the “profile of the proton beam” that generates neutrinos as a “by-product of collision with a target.”

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