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Neutrino oscillations measured with record precision

Result improves prospects for future experiments.

Eugenie Samuel Reich

08 March 2012

An elusive parameter quantifying the rate of oscillation of ghostly subatomic neutrinos from one type to another has been measured with precision for the first time.

Photomultiplier tubes line a detector chamber at the Daya Bay Reactor Neutrino Experiment in Guangdong province, China.

ROY KALTSCHMIDT, LAWRENCE BERKELEY NATIONAL LABORATORY

In a paper released online on 8 March, the Daya Bay Reactor Neutrino Experiment in southern China reports a measurement of the disappearance of antineutrinos produced in the world's fifth-largest nuclear power plant as they travelled about one kilometre between two sets of three 20-tonne, water-filled detectors. It finds that a parameter known as $\sin^2(2\theta_{13})$ is 0.092. Physicists had speculated that the quantity, the last of three 'mixing angles' that quantify rates of neutrino oscillation to be measured precisely, might be as low as zero. That would have made several future neutrino experiments that plan to compare the oscillation rates of neutrinos to those of antineutrinos virtually impossible to carry out; the positive result suggests that those are on firm territory to proceed.

"It's a happy surprise," says William Edwards of Lawrence Berkeley National Lab in California, who is the US project and operations manager for the experiment.

In 2011, measurements by the Japanese T2K neutrino experiment, by MINOS at Fermilab in Illinois and by the French reactor experiment Double Chooz, had all pointed to a non-zero value of the last mixing angle, but did so without reaching statistical significance. The Daya Bay measurement "is a perfect confirmation and a beautiful result," says Herve de Kerret of Paris 7 University.

Future planned experiments, including NOvA (NuMI Off-Axis Electron-Neutrino Appearance Experiment) at Fermilab, will compare the oscillations of neutrinos to those of antineutrinos in a bid to discover whether matter and antimatter behave in the same way. A finding that they do not — termed a violation of charge–parity (CP) asymmetry — might help to explain why there is so much more matter than antimatter in our universe. "Now we know this is non-zero we can go forward and hunt for CP violation," says Kam-Biu Luk of Lawrence Berkeley National Lab, who is co-spokesman for the experiment.

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The relatively large value of $\sin^2(2\theta_{13})$ has led the US Department of Energy (DOE), in its 2013 budget request to Congress, to speculate that NOvA might be able to resolve outstanding questions in neutrino physics. That might remove the need for a future, more ambitious neutrino experiment known as the Long Baseline Neutrino Experiment (LBNE), which will send a neutrino beam more than 1,000 kilometres across the United States to compare the rates of neutrino and antineutrino oscillations. A decision on whether

LBNE will go ahead is expected from the DOE later this year. Milind Diwan, co-spokesman for LBNE, says that the ability to cast light on CP violation is independent of the value of $\sin^2(2\theta_{13})$ — provided the parameter is not zero — and a large baseline experiment such as LBNE will be needed to measure it.

Nature doi:10.1038/nature.2012.10202

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2012-03-10 05:29 AM

Zephir Zephir said: These results could explain the superluminal neutrino results observed at MINOS and OPERA experiments. The antineutrino transforms into neutrino and back again and during this brief moment it behaves like so-called sterile or Majorana particle (sometimes called the Goldstone boson, too), i.e. like the gravitational wave without charge. Gravitational waves are superluminal in water surface analogy of spacetime in dense aether model, because they do play an analogy of underwater sound waves for surface ripples – so that the sterile neutrino makes a brief jump through space in this moment. Therefore such a result would be a very good confirmation of dense aether model as well.

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Nature ISSN 0028-0836 EISSN 1476-4687