Evidence for Massive Neutrinos

At Neutrino 98, the international conference that took place in Takayama, Japan in June, the Super-Kamiokande collaboration (made up of 23 institutions from Japan and the US) announced evidence for non-zero neutrino mass. If confirmed, it will force a revision of the Standard Model, which up to know has been able to describe all available data on particles and forces, *writes Marie-Claude Lemaire.*

Neutrinos are sub-atomic particles whose existence was postulated in 1930 by Wolfgang Pauli to solve the long-standing problem of the electron energy spectrum observed in β decay. It was only in 1956 that this particle was discovered by F. Reines and C. Cowan, who observed its interaction in a detector located near to a nuclear reactor at Savannah River, North Carolina in the US. These neutrinos were electron-neutrinos. In 1962, an experiment conducted by Leon Lederman, Melvin Schwartz and Jack Steinberger discovered a second class of neutrinos: the muon-neutrinos. In the Standard Model developed in the seventies, three families of neutrinos are expected. In 1990, one of the first results of the e^+e^- LEP collider, located at CERN, was that there are only three neutrino families. However, the Standard Model assumes zero-mass neutrinos. In the case of massive neutrinos, neutrinos from one family can transform into neutrinos of another family. As such a transformation is periodic, it is usually called neutrino oscillation. Despite great experimental efforts to track such oscillations the results up to now have been negative. The only hint of the existence of such oscillations has been the deficit of solar neutrinos.

The Super-Kamiokande result is a revelation. In this experiment the neutrinos are produced by the interaction of cosmic rays with the Earth's upper atmosphere. They are detected by the Cerenkov light produced by the electron or muon issued from their interaction within a 50,000-tonne tank of highly purified water located 1000 meters underground. Classifying the detected neutrinos into either electron-neutrinos or muon-neutrinos, the experimentalists observe a disappearance of muon-neutrinos into undetected tau-neutrinos. The rate of the measured effect suggests that the mass difference between the oscillating types is small ($\Delta m^2 = 10^{-2} - 10^{-3}$ eV^2).

If confirmed this discovery will strongly stimulate the new long-baseline experiments, in which it is planned to direct neutrino beams delivered by accelerators at CERN, FERMILAB and KEK to gigantic underground detectors located respectively in the Gran Sasso laboratory (Italy), SOUDAN laboratory (USA) and Super-Kamiokande detector (Japan).

Super-Kamiokande: opened in 1996, located in a zinc mine beneath the Japanese Alps, the massive tank of ultra-pure water registers a neutrino interaction every 90 minutes. A cone of light is then picked up by photo detectors that line the walls of the tank.

Heavy News

The news that may eventually shake up the Standard Model was followed a week later at the same conference mid-June by weighty hints that solar neutrinos may also have mass. The Super-Kamiokande collaboration reported that another study conducted in their 50,000-tonne water-filled detector had shown a deviation in the number of neutrinos produced by the sun at certain energy levels, which suggests that solar neutrinos can also change their identity in flight.

In addition to striking a blow at the Standard Model, the results may also have a profound impact on the problem of missing mass in the universe, and lead to a better understanding of the ultimate fate of the universe. (*Toby Chapman*)

Lasers & Optics meetings

numbers are telephone / fax

Optics for the Information Infrastructure
3 to 6 August 1998; Tianjin (China)
contact M.C. Guang, Institute for Modern Optics, Nankai Univ., 94 Weijin Road, Tianjin 300071, China
+86 22 2350 5503 / 22 2350 2974
imo@sun.nankai.edu.cn

School: Advances in Lasers and Applications
5 to 13 September 1998; St Andrews (Scotland)
contact Kisham Dholakia, School of Physics and Astronomy, University of St. Andrews, St. Andrews, Fife, Scotland KY16 9SS
- / +44 1334 463 104
kd1@st-andrews.ac.uk
Website star-www.st-and.ac.uk/physics/research/bds2/ala/ala.html

Conference on Lasers and Electro-Optics (CLEO/Europe) and European Quantum Electronics Conference (EQEC 98)
13 to 18 September 1998; Glasgow (Scotland)
contact Conferences Department, The Institute of Physics, 76 Portland Place, London W1n 3DH
+44 171 470 4800 / 171 470 4900
cleoeqec@iop.org

Quantum Optics: Atom Cooling and Guiding, Laser Spectroscopy and Squeezing
29 September to 4 October 1998
Castelvecchio Pascoli (Italy)
contact Head of the Euresco Unit, J. Hendekovic, European Science Foundation, 1 quai Lezay-Marnésia, 67080 Strasbourg Cedex, France
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And don't miss...

17th General Conference of the Condensed Matter Division *and* the 6èmes Journées de la Matière Condensée
Organized by the Condensed Matter Division of the EPS; 25 to 29 August 1998
Grenoble (France)
contact Secrétariat CMD17-JCM6, Laboratoire Louis Néel, BP 166 X,
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