16 September 2011

The OPERA experiment at the Gran Sasso Laboratory: do neutrinos travel faster than light?

The OPERA Collaboration has just completed a complex and accurate analysis of data taken in the last three years of operation at the Gran Sasso underground laboratory of INFN, 730 km away from the source of the CNGS muon neutrino beam produced by the CERN Super Proton Synchrotron.

The study was performed to measure with unprecedented precision the speed of CNGS neutrinos sent from CERN and reaching the detector at Gran Sasso after an approximate travel time of 2.4 milliseconds.

The astonishing result, that came really unexpected to the OPERA researchers, is that the more than 15 thousand neutrinos detected by the apparatus exhibit a tiny although significant difference with respect to the expected velocity: CNGS neutrinos reach OPERA about 60 nanoseconds before the time light would take to travel the same distance, indicating a neutrino velocity higher than the speed of light c by about 20 parts per million.

In order to perform this study, the OPERA Collaboration, together with experts from CERN and metrology institutions, performed a series of high precision measurements of distance and of neutrino time of flight. The distance between the origin of the neutrino beam and the OPERA detector was measured with an uncertainty of 20 cm over the 730 km travel path. The neutrino time of flight was determined with an accuracy of less than 10 nanoseconds by using sophisticated instruments including advanced GPS systems and atomic clocks. The time response of all elements of the CNGS beam line and of the OPERA detector has been measured with great precision, as well. This allowed keeping the systematic errors of the velocity measurement at a very low level.

The result is too surprising and the potential impact on science too large to draw immediate conclusions or attempt physics interpretations. The OPERA researchers and the entire community of particle physicists will have to conduct

additional studies with the aim of confirming the result and investigating the nature of the observed effect.

The OPERA experiment was inaugurated in 2006, with the main goal of studying the rare transformation (oscillation) of the muon neutrinos of the CNGS beam into tau neutrinos. One first such event was observed in 2010, proving the unique ability of the experiment in the detection of the elusive signal of tau neutrinos.

OPERA has been designed and is being conducted by a team of researchers from Belgium, Croatia, France, Germany, Israel, Italy, Japan, Korea, Russia, Switzerland and Turkey. The experiment constitutes a complex scientific enterprise that has been realised thanks to the skill of a large number of scientists, engineers, technicians and students, and with the strong commitment of the various actors of the project. In particular we mention the LNGS/INFN and CERN laboratories, and the major financial support of Italy and Japan with substantial contributions from Belgium, France, Germany and Switzerland.

The OPERA Collaboration presently includes about 160 researchers from 30 institutions and 11 countries:

IIHE-ULB Brussels, Belgium

IRB Zagreb, Croatia

LAPP Annecy, France
IPNL Lyon, France
IPHC Strasbourg, France

Hamburg, Germany

Technion Haifa, Israel

Bari, Italy
Bologna, Italy
LNF, Italy
L'Aquila, Italy
LNGS, Italy
Naples, Italy
Padova, Italy
Rome, Italy
Salerno, Italy

Aichi, Japan
Toho, Japan
Kobe, Japan
Nagoya, Japan

Utsunomiya, Japan

GNU Jinju, Korea

INR RAS Moscow, Russia
LPI RAS Moscow, Russia
ITEP Moscow, Russia
SINP MSU Moscow, Russia
JINR Dubna, Russia

Bern, Switzerland
ETH Zurich, Switzerland

METU Ankara, Turkey