Inauguration of second neutrino detector for Double Chooz experiment

October 23 2014

Work on a second neutrino detector has just been completed by CNRS and CEA near the Chooz nuclear power plant in northeastern France. Its measurements will supplement those of the first detector installed five years ago to study, as part of the Double Chooz experiment, the characteristics of neutrinos, highly elusive elementary particles produced in abundance in the sun and nuclear reactors. Built 400 meters from the reactor core of the nuclear power plant, the second detector was inaugurated on September 25, 2014 in the presence of representatives of CNRS, CEA and local authorities, who contributed to the effort.

After commissioning this fall, the detector will capture neutrinos produced in the cores of the two reactors at the power plant, located 400 meters away. This data will be compared with that collected by the other detector, installed one kilometer from the reactors. The anticipated difference in composition is due to a metamorphosis in the neutrinos, whose characteristics change during their trajectory. The Double Chooz experiment is basic for understanding this phenomenon, and making a contribution to the Standard Model of particle physics1.

Studying neutrino "flavors" with the help of nuclear power plants

Neutrinos, particles which are a million times lighter than electrons, are a byproduct of "beta" nuclear reactions. They are produced in nuclear reactors, as well as in the earth's crust and mantle, the human body, and the stars, with the sun being the most significant source of neutrinos on earth. They take any one of three forms or "flavors", as physicists say. But they have a surprising property, "oscillation", and change "flavor" by moving, depending on energy and distance traveled. These "oscillations" depend on three parameters (called "mixing angles"), two of which are known with a fair measure of accuracy. The third is much smaller and difficult to measure accurately, and this is the focus of the Double Chooz experiment.

Double Chooz Experiment

The Double Chooz project began in 2003 as part of an international collaboration2, at the initiative of researchers from CEA and CNRS. In 2009, the first detector was installed in an underground laboratory built by EDF in the 1990s one kilometer from the reactor cores of the nuclear power plant. In 2011, this arrangement resulted in detecting the transformation of neutrinos in flight, a discovery confirmed in 2012 by other international experiments. Since then, there has been a worldwide race to accurately measure the third neutrino mixing angle. At Chooz, the commissioning of a second detector will enable researchers to make an effective contribution. Within three years, the missing parameter should be measured with 10% accuracy.

Just like the first detector, the second consists of a cylindrical vessel of 10,000 liters filled with a mixture of mineral oils. Such a volume is required because neutrinos interact very little with matter: they traverse walls, mountains, and living beings with practically no interaction. To detect one, a large quantity of matter must be placed in the path of the neutrinos. Each day, this instrument will detect only some 300 neutrinos of the hundreds of quintillions that traverse it. In addition, the detector is buried under 50 meters of rock and protected by several concentric enclosures to isolate it from cosmic radiation and natural ambient radioactivity.

Comparison of the results of Double Chooz with those from similar experiments in China (Daya-Bay) and South Korea (RENO) and particle accelerators (T2K in Japan) will facilitate the design of projects to explore the origin of the asymmetry between matter and antimatter observed in the universe. According to the theory of the Standard Model, which predicts the behavior of matter since the beginning of the universe, the Big Bang should have created as much matter as antimatter 13.7 billion years ago. But there is an overabundance of matter observed today. Neutrinos may hold the key to this mystery.

Provided by CEA