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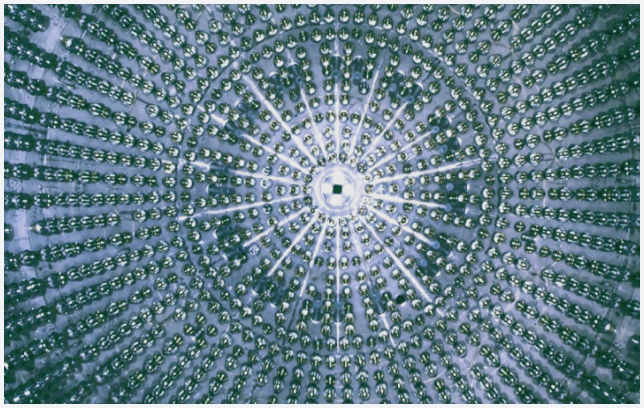

SOX AND THE CHALLENGE OF STERILE NEUTRINOS

SOX (Short distance Oscillations with boreXino) is a project whose scientific objective is to confirm or clearly confute the phenomenon of the so-called "neutrino anomalies" observed by certain experiments worldwide, which have measured an “anomalous” disappearance of some of these particles in neutrino flows. An explanation of the phenomenon might lie in the existence of sterile neutrinos, particles hypothesised based on certain as yet unobserved theories, which differ from the neutrinos we know today due to some of their characteristics: for example, they would appear to interact with matter solely through gravity and not through weak forces.

The SOX project, designed to identify sterile neutrinos, envisages work in tandem of an antineutrino generator and of the Borexino experiment, a highly sensitive neutrino and antineutrino detector in operation since 2007 at INFN's Gran Sasso underground Laboratories, protected from cosmic rays thanks to the 1400 metres of rock of the massif above it. The very high level of radiopurity (i.e. the almost total absence of radioactivity), the large dimensions and the proven ability to measure both neutrinos and antineutrinos with great precision make Borexino the ideal tool to accomplish this research.

The SOX antineutrino generator, which will be manufactured in Russia based on the most up-to-date techniques, will contain a solid powder Cerium-144 source which, spontaneously decaying, will produce the antineutrinos needed for the experiment. The Cerium-144 source will be sealed in a double steel capsule, which in turn will be shielded by a tungsten shield weighing over 2.4 tons and with a thickness of 19 cm, specially made for SOX, in order to prevent the gamma rays, produced together with the neutrinos in the decays, from dispersing outside. The antineutrino generator will then be placed near Borexino, in a housing that will completely eliminate gamma ray emissions, which would irremediably pollute the rare signals left by the neutrinos. The goal of the SOX generator, in fact, is to produce only and exclusively

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antineutrinos, because even the smallest presence of radioactivity would be fatal for the success of the experiment: total isolation of the antineutrino generator from the outside is an indispensable condition for implementation of the project and also of all other research activities in the Gran Sasso underground Laboratories.

Sterile neutrinos. There are three types of neutrinos: electronic, muonic and tau which, when interacting with matter, can produce electrons, muons and tau particles, respectively. However, neutrinos can switch from one type to another: this phenomenon is called neutrino oscillation. Certain neutrino detectors worldwide have observed an anomaly in this oscillation process in electronic neutrino flows, measuring the disappearance of some of these particles. This anomaly can be explained by the existence of so-called sterile neutrinos. The discovery of these particles would have profound implications for the understanding of the universe and of fundamental particle physics. The sterile neutrino would, in fact, open up a new era in physics and cosmology, since it would be the first particle to be discovered not included in the Standard Model, which is our current theory that describes the elementary particles and the interactions that regulate their behaviour. In the event of a negative result, on the other hand, the experiment would be able to definitively close a long debate on the anomalies of the neutrino. Moreover, it could explore the existence of a new physics in low energy neutrino interactions, provide a measurement of the magnetic moment of the neutrino and allow an exceptional calibration of the Borexino detector, very useful for future high-precision measurements of solar neutrinos. ■