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Neutrino Mass in Europe

A. Giuliani

andrea.giuliani@csnsm.in2p3.fr

CNRS / CSNSM, France

ABSTRACT

The absolute neutrino mass scale, inaccessible to oscillation experiments, can be addressed through laboratory searches, such as the investigation of neutrinoless double beta decay ($0\nu\beta\beta$) and the study of the single beta decay. A rich experimental program is ongoing in both sectors in Europe. $0\nu\beta\beta$ is a hypothetical rare nuclear transition in which a metastable isobar changes into a more stable one by the simultaneous emission of two electrons and nothing else. Its observation would imply the violation of the lepton number conservation and establish the Majorana nature of neutrino. If the process is mediated by the exchange of light Majorana neutrinos, the decay rate would be proportional to the square of the so-called effective neutrino mass m_{ee}, which fixes the neutrino mass scale.

The current sensitivity to m_{ee} is around 0.2-0.5 eV. A much debated claim of evidence in ^{76}Ge corresponds to $m_{ee} \approx 0.3$ eV. Experiments under commissioning or construction in Europe can start to explore the so-called inverted hierarchy region, with sensitivities around 0.1-0.05 eV. CUORE will be an array of natural TeO_2 bolometers arranged in 19 towers and operated at 10 mK in the Laboratori Nazionali del Gran Sasso. The source corresponds to 200 kg of the isotope ^{130}Te. CUORE is in the construction phase and data taking is foreseen to start in 2013/2014. In parallel to CUORE, a rich R&D program on scintillating bolometers is under way (LUCIFER experiment). This approach has the potential to extend further the sensitivity of low temperature macro-calorimeters. GERDA is an array of enriched Ge diodes operated in liquid argon and shielded by an active water Cerenkov veto. The experiment, installed in the Laboratori Nazionali del Gran Sasso, has the possibility to scrutinize the ^{76}Ge result in a short time. The first phase (just started) consists of 18 kg of isotope. The second phase foresees 40 kg of isotope. SuperNEMO, which is foreseen to be installed in the planned extension of the Laboratoire Souterrain de Modane, will provide excellent electron track reconstruction, providing the unique opportunity to study the $0\nu\beta\beta$ mechanism. It will investigate ^{82}Se and possibly ^{150}Nd and ^{48}Ca in a second phase. The first module, operating as a demonstrator, is foreseen in 2013. NEXT is a proposed 100 kg high-pressure gaseous-xenon TPC, to be located in the Laboratorio Subterràneo de Canfranc and aiming at the study of the isotope ^{136}Xe. The extension to 1 ton is technically possible. Clear two-track signature is achievable, thanks to the use of gaseous rather than liquid Xe.

In direct neutrino mass measurements, the undisputed leadership belongs to KATRIN, a large electrostatic spectrometer with magnetic collimation. This apparatus is in construction in the tritium laboratory (Karlsruhe) and will study the end-point of the tritium beta decay. The predicted sensitivity to neutrino mass is 0.2 eV at 90% CL, with a discovery potential of 0.35 eV at 5σ. A different approach is adopted in the MARE project (in the R&D phase in Milano and Genova): arrays of low-temperature micro-calorimeters are operated with a very low transition energy source embedded in them, like ^{187}Re (beta decay) or ^{163}Ho (electron capture). Sub-eV sensitivity to neutrino mass is possible: in addition, the modular approach intrinsic to the bolometric technology does not set intrinsic limitations to the expansion of the experiment.
In this paper, the aforementioned experiments will be reviewed and the short/mid-term prospects of the neutrino mass searches in Europe will be discussed.