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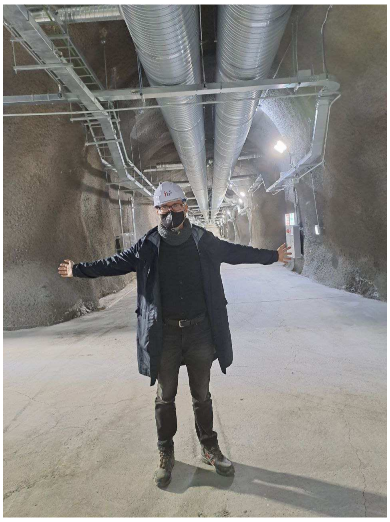
“Directions of investigation in underground neutrino laboratories worldwide”



The are several directions of investigation in underground neutrino laboratories worldwide:

1) Neutrino telescopes. Observation of:
- solar neutrino
- atmospheric neutrino
- supernova neutrino
- reactor neutrino
- neutrino produced in accelerator fixed-target experiment

The fundamental discovery (Nobel Prize 2015) in this field is the neutrino oscillations, meaning that the neutrino can change its flavor. The proof was done in accelerator experiments when a neutrino beam produced in an accelerator experiments (OPERA, Gran Sasso/ SPS, CERN; T2k/Super-Kamiokande) directed across the Earth to a detector. The fundamental conclusion which follows from neutrino oscillations is a non-zero neutrino mass. The neutrino mass is so small that by now it was impossible to measure but just to put limits (<0.120 eV).

Another fundamental question that can be tasted in the future accelerator-based experiments (such as LBNE/DUNE/Fermilab) is the existence of sterile neutrino, i.e. massive neutrino, probably non-interacting with a matter but oscillating like the known types of neutrino. The lack of the latter could be a hint for the existence of this new particle. Sterile neutrino is one of the candidates for the dark matter.

2) Search for 0νββ decay

A fundamental problem is the nature of neutrino whether they are Dirac or Majorana fermions. Though the observable difference between tends to 0 if the neutrino mass also tends to 0, a non-zero neutrino mass proved by the discovery of the neutrino oscillations makes these investigations reasonable.

Majorana neutrinos are identical to their antiparticles while the Dirac ones are not. One of the best ways to discriminate between these two types is the observation neutrino-less double beta decay 0νββ, which is possible only for Majorana neutrino.

3) Dark matter search

Dark matter is more than a quarter of matter in Universe observed by now only in gravitational interactions by measuring of the internal dynamics of the galaxies and comparing it with the gravitational law. The fluid-dynamics simulations of galaxies formation and dynamics itself provides a lot of useful information about the dark matter and star formation as well. Both the dark matter density and the star formation rate is a measurable value that can be compared with the simulation results. This kind of simulations requires High Performance Computing and its precision depends on the minimal grid element size which can be reduced by using of more computational resources. The current results show that the dark matter density is not a constant and can vary for different galaxies. The most interesting objects are the dwarf galaxies (satellites) in which the dark matter density is much higher than the average level. These objects are of worth for investigation. There are different dark matter candidates.

4) Yemilab underground laboratory (IBS, Korea) being currently under construction will host the experiments dedicated to all 3 directions of investigation.