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Laboratory Search for Cosmological Dark Matter

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In recent years, measurements of the red shift of light from distant Supernova explosions, new observations of the cosmic microwave background with unprecedented precision as well as galaxy redshift surveys of hundreds of thousand of galaxies have revealed an expanding Universe almost completely filled with Dark Energy and Dark Matter. Although there are good motivations from theoretical and experimental particle physics for the existence of Dark Matter in form of non-baryonic elementary particles, we have only restricted or very little information from direct investigations on these particles.

The two major candidates for Dark Matter particles are the well-known neutrinos and the yet unknown so-called WIMPs, weakly interacting massive particles. Whereas the first are very light and thus considered as "Hot Dark Matter", WIMPs are expected to be very massive and would thus be "Cold Dark Matter".

The observation of neutrino oscillations is an unambiguous proof of a non-zero neutrino mass. However, the absolute mass scale cannot be extracted from such experiments. The most sensitive laboratory search on the neutrino mass is the investigation of the kinematics of the ß decay, especially the decay 3H ⊠⊠3He + e- +anti(⊠e). At the Forschungszentrum Karlsruhe, the KArlsruhe TRItium Neutrino experiment KATRIN is under construction to improve the existing sensitivity on the neutrino mass by more than one order of magnitude down to 200meV. Thus, KATRIN will be able to decide whether neutrinos play a significant role in the structure formation of the early Universe.

About 23% of the Universe´s mass content should be in form of Cold Dark Matter. WIMPs as particle candidates for this contribution would have formed the seeds of galaxy formation in the early Universe and would hence also form the Dark Halo surrounding our galaxy, the Milky Way. One attempt to detect them is the measurement of the energy released in elastic scattering of these halo WIMPs off nuclei of the detector material. The Forschungszentrum Karlsruhe is involved in the EDELWEISS direct Dark Matter search experiment installed in the Laboratoire Souterrain de Modane in the French-Italian Fréjus tunnel. The detectors used in EDELWEISS are Ge crystals of 320g mass operated at a temperature of 17mK.

In this lecture, we shortly review the cosmological motivation for particle Dark Matter and describe in detail the physics scheme, the experimental set-ups and technical challenges for laboratory Dark Matter search with KATRIN and EDELWEISS.

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