



Contribution ID: 80

Type: **not specified**

Direct Directional Dark Matter Search

Wednesday, 7 September 2022 15:20 (20 minutes)

In the last decades, the existence of Dark Matter (DM) has become well established, even though its nature is still elusive and unknown. The majority of the experiments searching for a direct signature of DM look at the energy of nuclear recoils induced by scattering with DM candidates. However, the motion of the Earth in the Galaxy produces an apparent wind of DM particles coming from the constellation Cygnus, making the direction of these nuclear recoils a very peculiar feature. The

measurement of the directional information would greatly benefit the field, for example by enabling the rejection of neutrino coherent scattering with nuclei (CEvENs) which will reduce the sensitivity of experiments that only measure energy. Moreover, the angular distribution is expected to have a clear dipole structure, key for positive identification of DM, and even DM astronomy. Directionality can also help in signal to background discrimination for faster discovery. We will review the present R&D on different experimental approaches that try to attain directional measurements and we will focus on those which have actually demonstrated directionality at the recoil energy of interest for DM, i.e. nuclear emulsion and gaseous Time Projection Chambers (TPC).

In the context of the gaseous TPC approach, we will illustrate the latest developments within the different existing projects, from gas and amplification stages optimization, to detector simulation, tracking algorithms and performance studies. We will also show the prospect of the realisation of CYGNUS, whose goal is to eventually establish, through a staged approach and installation in multiple underground laboratories, a Galactic Directional Recoil Observatory at the ton-scale.

CYGNUS could test the DM hypothesis beyond the Neutrino Floor and measure the coherent scattering of neutrinos from the Sun and possibly Supernovae.

During the talk, we will discuss the present state of the directional DM search, outline the status of current detectors, and review the recent results from R&D projects.

Summary

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Session Classification: Direct DM searches