
Dark Matter (WS 2017/18) - Problem sheet 7

Lectures: Prof. Manfred Lindner and Dr. Giorgio Arcadi

Tutorials: Dominick Cichon

Time: Wd. 09:15 - 11:00

Venue: Philosophenweg 12, KHS

Deadline for this sheet: 17.01.2018

1 Detecting dark matter with liquid noble gas detectors

In this problem sheet, the XENON1T experiment is being looked at to provide an example for a liquid noble gas direct detection experiment. Read [arXiv:1708.07051](https://arxiv.org/abs/1708.07051) and answer the following questions (do not get lost in the technical parts of the paper):

1.1 Liquid xenon (LXe) time projection chambers (TPCs) *5.5 Points*

1. Which kinds of interaction with the xenon target can incoming particles have? Which one of these are WIMPs expected to typically undergo?
2. What are S1/S2 signals, and how are they generated? Is all of the energy deposited by a particle converted into these signals? Why / why not?
3. Which information can one extract from the S1 signal of an interaction in conjunction with the S2 signal to which it belongs? What is this information used for? State 3 examples.
4. Why does the xenon need to be continuously purified?
5. What is "self-shielding"? Why does one need to use radioactive sources which mix with the xenon target itself to calibrate the entire detector volume instead of using sources outside of the TPC?

1.2 Background sources *4.5 Points*

1. Why is the detector located deep underground?
2. Why is not the entire volume of the TPC used for WIMP searching? What could be done to allow for usage of a larger volume?
3. Why is the xenon being distilled? Why cannot the rare-gas purifiers of the purification system be used instead of relying on distillation?
4. Which background source (for a nuclear recoil energy region from 4 to 50 keV and a fiducial target of 1.0 t) is dominant after applying electronic recoil background rejection (with a typical discrimination fraction as stated in the paper), and what is the expected rate of background events caused by it then?
5. What is the "neutrino floor"? What kind of signature could help with overcoming it, and why? (Hint: Think back to the last couple of lectures given by Prof. Lindner.)