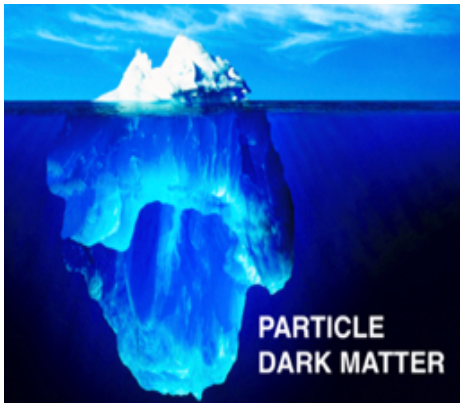
Dark Matter sensitivity studies without astrophysical assumptions

Background

Gravitational anomalies observed in astrophysical and cosmological systems point towards the existence of large amounts of invisible and unidentified mass, or Dark Matter (DM), in the universe [1]. While the evidence for DM is strong, its nature remains a mystery: what is DM made of?



In the leading paradigm, DM is made of hypothetical, yet undiscovered particles. Low-background experiments currently operate deep underground trying to catch the elusive particles forming our Milky Way “DM halo” while they bounce off, e.g., the electrons bound to a crystal detector.

An important feature of these experiments is their sensitivity: the smallest DM-electron coupling they can probe. While estimates of this experimental sensitivity depend on the poorly known properties of our galactic DM halo, methods were recently proposed to circumvent this limitation [2].

Description of the project

By combining analytical and computational methods, in this project you will develop and apply a formalism that will allow you to estimate the sensitivity of the existing DM search experiments without making any assumptions on the properties of the Milky Way DM halo. The formalism will apply to general DM-electron interactions in crystal detectors. Specifically, in the first part of the project you will analytically express the rate of DM-induced electronic transitions in crystal detectors as the product of two distinct factors: the first one depending on the DM halo properties, the second one depending on the DM particle and detector properties. In the second part of the project, you will exploit this factorization to analyze the results recently reported by the SENSEI and EDELWEISS DM search experiments in a “DM halo-independent way”.

The report will be written in Swedish.

Methods

The project involves basic quantum mechanical calculations and numerical computations.

Group structure

The project has been designed for one group of 3-6 students.

Literature

[1] “A History of Dark Matter”, G. Bertone and D. Hooper; arXiv:1605.04909.
[2] “Halo-Independent Dark Matter Scattering Analysis with In Medium Effects”, M. Chen, G. Gelmini and V. Takhistov; arXiv:2209.10902.

Target groups: F, GU-fysik

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