Dark Matter absorption in dielectric materials

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.

One way to detect the DM particles travelling through our galaxy or produced in celestial bodies is via their absorption in detector materials – a process that is analogous to the photoelectric effect [2].

Description of the project

What is the expected rate of DM absorption in materials? What are the material properties that maximize this rate? Finally, is there a theoretical upper bound on the rate of DM absorption in materials?

In this project you will address these questions by combining analytical calculations with numerical simulations. The analytical calculations will rely on the basic principles of Quantum Mechanics, and focus on expressing the rate of DM absorption in materials in terms of the dielectric function – an observable quantity which measures the response of a given material to an external perturbation coupling to the electron density. The numerical calculations will focus on simulations of DM absorption in dielectric materials performed with the DarkELF code [3].

The research addressed in this project is interdisciplinary in nature and combines concepts from particle and solid state physics. It will thus provide you with tools which you will be able to apply to a wide range of topics in your future studies, from high-energy to condensed matter physics.

The report will be written in Swedish.

Methods

The project involves basic quantum mechanical calculations and numerical simulations.

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] "Searching for Dark Absorption", I. M. Bloch et al., arXiv:1608.02123".
[3] "DarkELF", S. Knapen et al.; arXiv2104.12786 ".

Target groups: F, GU-fysik

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