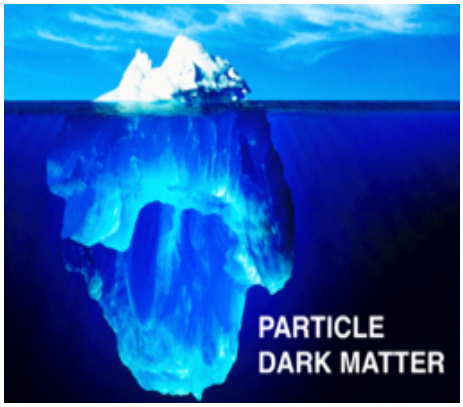
TIFX04-22-24

Dark Matter-induced electronic transitions in detector 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 of modern cosmology DM is made of hypothetical, yet undiscovered particles. Ultra-sensitive detectors operate deep underground trying to catch the particles forming our galaxy's DM component while they bounce off atomic nuclei or electrons crossing a detector.

For each DM particle model, there is a theoretical upper limit on the rate of DM-induced electronic transitions in detector materials [2]. What are the materials that can saturate this limit?

Description of the project

In this project you will calculate the rate of DM-induced electronic transitions in materials used in operating DM experiments. You will express this rate as a function of the detector material dielectric function, which provides a quantitative measure of the material's response to an external electron density perturbation. By using existing parametric models for the dielectric function, you will determine under what conditions a given material can saturate the upper limit found in [2]. Finally, you will explore the dependence of your results on the assumed DM particle model. This study is an important contribution to the identification of optimal DM detection materials.

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] "DM-electron scattering in materials: sum rules and heterostructures", R. Lasenby and A. Prabhu; arXiv:2110.01587.

Target groups: F, GU-fysik

Supervisor

Riccardo Catena, Associate Professor at the Department of Physics; catena@chalmers.se, Origo, room: 6103A