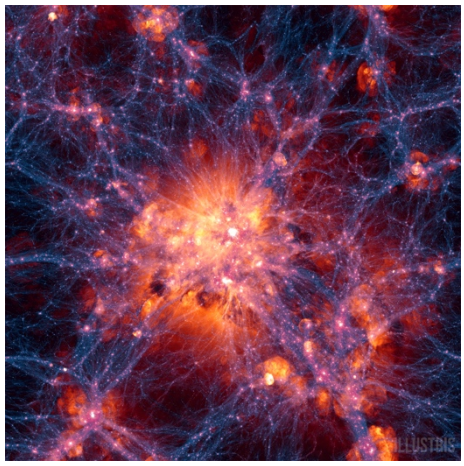
Fourier analysis of Dark Matter signals in crystals

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. 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. Large detectors have been built deep underground to try to catch the particles forming our galaxy's DM component while they bounce off atomic nuclei or electrons crossing a detector.

The search for DM-induced electronic transitions in semiconductor crystals plays a central role in this context.

Description of the problem

In this project you will calculate the expected rate of DM-induced electronic transitions in silicon and germanium semiconductor crystals. You will then investigate how the result depend on time by performing a Fourier series expansion of the predicted rate, and determining the relative size of the terms in this expansion. Through this calculation, you will estimate the number of DM signal events that a given detector has to observe to reconstruct the first few terms in the rate expansion, thereby providing and an important input to next-generation DM experiments.

Implementation

The project involves basic quantum mechanical calculations and numerical computations.

Group structure

The project has been designed for one group of 4-6 students.

Literature

Introductory reading: "A History of Dark Matter", G. Bertone and D. Hooper; arXiv:1605.04909

Target groups: F, GU-fysik

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