Searching for dark matter in the Earth’s shadow

Background
Increasingly accurate cosmological and astronomical data reveal that the Universe is to a large extent made of a non-luminous substance called dark matter (DM). The nature of DM remains a mystery, but indirect evidence points towards a new hypothetical particle as the prime candidate.

Experiments located deep underground are currently searching for DM particles from the Cosmos. So far, DM particles have escaped detection, but the next decade of searches in the field is widely believed to be pivotal.

In the standard paradigm of astroparticle physics, DM interacts with nuclei and/or electrons in the Earth’s interior while approaching a detector deep underground. Because of this interaction, the predicted DM velocity distribution in space and the one on Earth are different — an effect known as Earth-shadowing.

The Earth-shadowing effect might hold the key to unveiling the nature of DM.

Description of the problem
You will calculate the difference between the DM velocity distribution in space and the one on Earth (Earth-shadowing effect) assuming that DM primarily interacts with electrons while crossing our planet. This analysis complements previous studies which entirely focused on DM scattering off nuclei. The project is motivated by the fact that DM-electron interactions could be important, e.g., if DM is lighter than a proton. Your calculations will have multiple applications. For example, you will be able to predict the rate of DM-electron interactions in underground detectors as a function of time and of the detector position on Earth. These predictions can be tested at present and future DM experiments.

A successful bachelor project on the proposed topic is expected to lead to a publication in an international scientific journal.

Implementation
The project involves analytic calculations based upon quantum mechanics and scattering theory, and simple numerical computations.

Group structure
The project has been designed for a group of 3-4 students.

Literature

Target groups: F, GU-Fysik

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