Dark matter avoids detection – Finnish scientists join a new serch project

As a joint European effort, the COSINUS experiment will be constructed 1400 meters deep below the Gran Sasso massif to trace the hidden side of the universe, dark matter. Finnish scientist will take part in the theoretical analysis of the measurements.

Even though dark matter is five times as abundant as ordinary matter in the universe, it has only been indirectly observed via gravity. Except for one signal, measured in the DAMA-experiment for over 20 years.

Dark matter surrounds the center of our galaxy like a cloud. Because our solar system revolves around the galaxy, and the Earth revolves around the Sun, the signals of the bombardment by dark matter should vary through the seasons. During the summer the Earth moves against the dark matter wind and the bombardment should therefore be more rapid.

The DAMA-experiment has observed exactly this variation in the signal – a sign of dark matter. But no other experiment has been able to reproduce this observation. To be taken as true evidence, a scientific result has to be confirmed.

A flash of light and an increase in temperature

The scientist aim to confirm the observations made by the DAMA experiment with the new COSINUS experiment. It will be constructed in the Italian national laboratory of Gran Sasso, 1400 meters underground where it will be shielded from cosmic radiation that would obstruct the measurements.

The DAMA experiment uses sodium iodide crystals as detectors. Also COSINUS will use sodium iodide crystals, which will be cooled close to the absolute zero temperature of -273 °C. COSINUS can distinguish between hits from different types of particles. When a dark matter particle hits the detector it leaves two traces: a short flash of light and an extremely small increase in temperature, which can be detected with a special thermometer.

COSINUS will detect nuclear scattering events in the sodium iodide crystal above one keV energy. By combining the results of the light and temperature measurements it is possible to find out what kind of scattering process has taken place. If the scattering events behave as theoretically predicetd for dark matter, the observation of dark matter will be confirmed.

The COSINUS experiment consists of a cylindrical water tank, with height and diameter of 7 meters. The tank is filled with ultra-pure water to shield from natural radioactivity. Above the tank, a cleanroom will be constructed for hadling and installing the detector equipment. The construction will begin in 2021 and the first measurements will begin in 2022. The first results are expected in 2023.

Will the observations confirm the theoretical models?

The project is funded by the Italian INFN, the Max Planck Society of Germany, the Austrian HEPHY and the Technical University of Vienna, and the Helsinki Institute of Physics (HIP), which joined the experiment in 2020.

The finnish researchers will take part in theoretical analysis of the results, analysing how the data produced by the COSINUS experiment should be interpreted in terms of theoretical models for dark matter.

– This is an excellent opportunity to combine our expertise in solid state physics with that of particle physics, explains professor of computational materials physics **Kai Nordlund** from University of Helsinki.

– We are using theoretical models and atomic level simulations to understand the formation and transport of heat in the sodium idodide crystal. These models were originally developed for the purposes of ordinary solid state physics, but a few years ago we discovered how these models can be utilized to understand the interactions between dark matter particles and detector materials, Nordlund continues.

– We will determine which models of dark matter are ruled out by the experimental data, and which models are be supported by it, says university researcher **Matti Heikinheimo** from University of Helsinki and HIP.

The idea for the experiment occured in 2015 to **Karoline Schäffner** (Max Planck Institute) and **Florian Reindl** (HEPHY and Technical University of Vienna). Under their supervision the sodium iodide detectors have been tested and developed for the COSINUS experiment. They have achieved what no one else could, to show that the sodium iodide detector can be operated in a very low temperature.

Further infomation:

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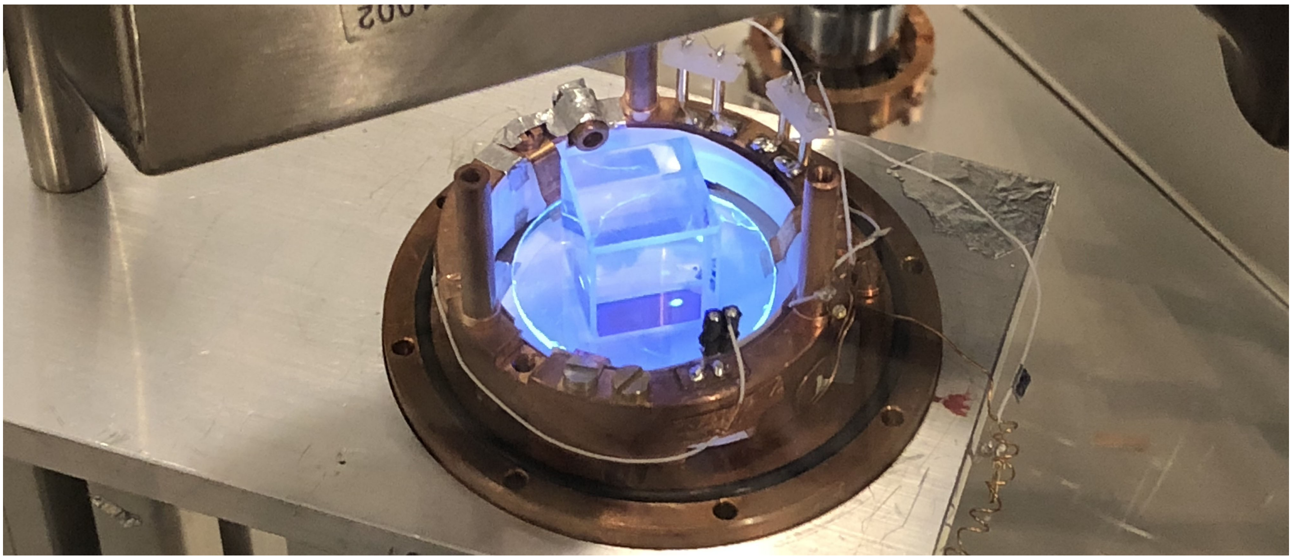
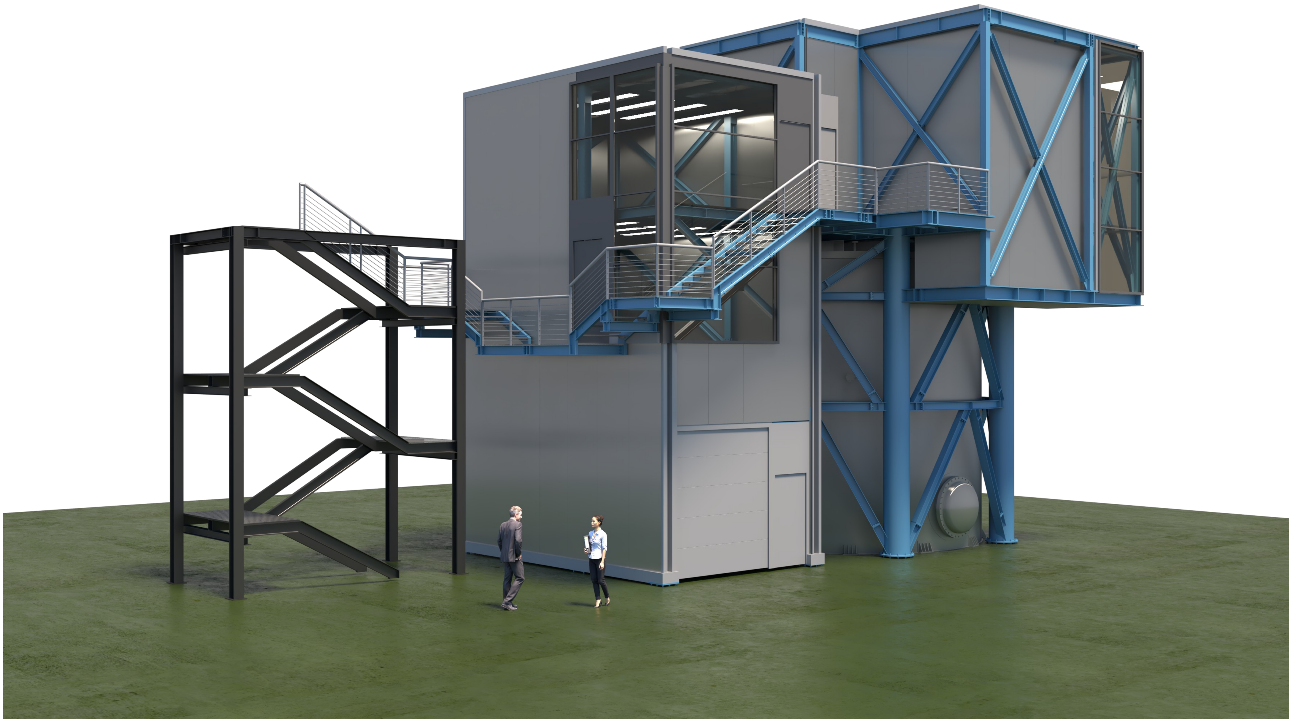


The detector, consisting of a sodium iodide crystal, is cooled close to the absolute zero temperature (-273 °C).



The COSINUS experiment, containing a cylindrical water tank and the cleanroom to be constructed above it.

Images: COSINUS/Karoline Schäffner