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Cryogenic light detectors for background suppression: the CALDER project

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Content

Background rejection plays a key role for experiments searching for rare events, like neutrino-less double beta decay (0 DBD) and dark matter interactions. Among the several detection technologies that were proposed to study these processes, cryogenic calorimeters (bolometers) stand out for the excellent energy resolution, the ease in achieving large source mass, and the intrinsic radio-purity. Moreover, bolometers can be coupled to a light detector that measures the scintillation or Cherenkov light emitted by interactions in the calorimeter, enabling the identification of the interacting particle (alpha, nuclear recoil or electron) by exploiting the different light emission. This feature allows to disentangle possible signals from the background produced by all the other interactions that, otherwise, would dominare the region of interest, preventing the achievement of a high sensitivity.

Next generation bolometric experiments, such as CUPID, are demanding for very competitive cryogenic light detectors. The technology for light detection must ensure an RMS noise resolution lower than 20 eV, a wide active surface (several cm^2) and a high intrinsic radio-purity. Furthermore, the detectors have to be multiplexable, in order to reduce the number of electronics channels for the read-out, as well as the heat load for the cryogenic apparatus. Finally they must be characterized by a robust and reproducible behavior, as next generation detectors will need hundreds of devices. None of the existing light detectors satisfies all these requests. In this contribution I will present the CALDER project, a recently proposed technology for light detection which aim to realize a device with all the described features.

CALDER will take advantage from the superb energy resolution and natural multiplexed read-out provided by Kinetic Inductance Detectors (KIDs). These sensors, that have been successfully applied in astro-physics searches, are limited only by their poor active surface, of a few mm^2. For this reason, we are exploiting the phonon-mediated approach: the KIDs are deposited on an insulating substrate featuring a surface of several cm^2. Photons emitted by the bolometer interact in the substrate and produce phonons, which can travel until they are absorbed by a KID.

The first phase of the project was devoted to the optimization of the KIDs design, and to the understanding/suppression of the noise sources. For this phase phase we chose a well-known material for KIDs application, aluminum, which according to our detector model allows to reach a noise resolution of about 80 eV RMS. In the second phase we are investigating more sensitive materials (like Ti, Ti-Al, TiN) which will allow to reach the target sensitivity.

In this contribution I will present the results obtained at the end of the first project phase in terms of efficiency and energy resolution, and I will present the encouraging results obtained at the beginning of the second project phase.

Summary

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