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Background of X-ray TES micro-calorimeter arrays for elusive particle experiments

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To achieve the extreme sensitivities necessary to perform elusive particle searches like β-decay spectroscopy for neutrino mass measurement or dark matter detection, future experiments will employ large arrays of cryogenic detectors, such as metallic-magnetic calorimeters or transition-edge sensors (TES).

A TES is a thin film of superconducting material weakly coupled to a thermal bath typically at $T < 100$ mK, that can be used as a radiation detector by exploiting its very sharp phase transition. We have been developing X-ray TES micro-calorimeters optimized for X-ray astronomy up to energies of 12 keV, as well as a frequency-domain multiplexing (FDM) technology to perform their readout. Energies up to $\sim$10 keV are compatible with the expected spectrum of axion-like particles arriving on Earth generated in the Sun by electron processes and Primakoff conversion, which will be investigated in the future by axion helioscopes. A fundamental instrumental requirement is the background of the X-ray detectors, which should be at a level of 10^{-7} keV^{-1}cm^{-2}s^{-1}. TES represent a suitable choice for this science case, given their high energy resolution and quantum efficiency, low intrinsic background and scalability to large ($\sim$ 1000s) arrays.

In this contribution we present a measurement of the X-ray detectors background, using a TES array with 240×240 μm^2 absorber area and energy resolution at a level of 2 eV at 5.9 keV with an FDM readout. With an effective integration time of 40 days, we measured a background rate at a level of 10^{-3} keV^{-1}cm^{-2}s^{-1} in the energy range of 1 to 10 keV.

We show the data analysis method and prospect possible improvements, such as coupling with a cryogenic anti-coincidence and the introduction of a PTFE and Cu shielding around the sensitive area of the setup, to further reduce the background rate.

Collaboration

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