Development of Cryogenic Detectors for Astro Particle Physics ◇

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This summary reflects the progress in the development of cryogenic detectors for particle and radiation detection in astro-particle physics experiments. In part, this research was done in the frame of two large-scale applications being performed at Gran Sasso. This is the CRESST dark matter search and the GNO solar neutrino experiment. In addition, it led to a substantial improvement of fundamental detector properties, which opens new prospects for other applications like X-ray spectroscopy and neutrino mass searches.

1. Search for WIMP dark matter

Our group is involved in the CRESST Experiment (Cryogenic Rare Event Search with Superconducting Thermometers), a search for dark matter candidates via detection of nuclear recoils. We have been developing massive cryogenic detectors which use a superconducting phase transition thermometer evaporated directly onto a dielectric crystal. The energy deposited in the crystal by a single particle interaction is measured via the resulting temperature rise in the thermometer. The device is operated in the transition region of the superconducting to the normal conducting state of the thermometer, where a small temperature rise ΔT of the thermometer leads to a large increase ΔR of its resistance. In its present setup CRESST operates four Al_2O_3-crystals of 262 g each, equipped with tungsten phase transition thermometers which have been fabricated at the MPI für Physik, Munich. During 1997 the installation of the experiment at the Gran Sasso National Laboratory has been completed. First detector tests with the full apparatus have already been performed [7]. They demonstrated that the envisaged energy threshold of 500 eV and an energy resolution better than 250 eV (FWHM) for 5.89 keV X-rays could be achieved.

2. Solar Neutrino Detection

For the second phase of the GNO (Gallium Neutrino Observatory) experiment, which at present uses 30 tons of gallium for solar neutrino detection via the reaction $^{71}\mathrm{Ga} + \nu_e \rightarrow {}^{71}\mathrm{Ge} + e^-$ with subsequent counting of the X-rays and Auger electrons associated with the ^{71}Ge EC-decay, we are developing a new detection concept based on low temperature calorimeters. The goal is to improve both the statistical and systematic accuracy of the counting process with respect to the status achieved with miniaturized low level proportional counters in GALLEX [1]. First results obtained with test detectors did already serve to demonstrate an improvement by more than a factor of five in energy resolution [5]. This ongoing R&D project currently focusses on meeting the technical requirements for implementation of the new concept into the large-scale experiment at Gran Sasso [2].

3. Development of low temperature calorimetric detectors

In 1997 the development of low temperature calorimetric detectors was pursued, focussing on both, better understanding and improvement of fundamental detector properties, and exploration of promising future applications. For future use in CRESST, we proceeded further towards constructing a detector which allows for discrimination between ionizing interactions and nuclear recoils [6]. Such a device would allow to increase substantially the sensitivity of CRESST. Another line of investigation was the development of high-resolution calorimeters with absorber masses in the mg-range. With an Au-absorber and an Ir/Au-thermometer we obtained a resolution of 28 eV (FWHM) at 5.89 keV [6].

4. Development of superconducting tunnel junction detectors

For X-ray detection we develop detectors based on superconducting tantalum absorber films in combination with aluminium **S**uperconducting **T**unnel **J**unctions (STJs). The latter serve as readout elements for excess quasiparticles created from X-ray absorption. An energy resolution of 27 eV (FWHM) for 5.89 keV X-ray absorption in a single STJ could be achieved [3]. With a position sensitive detector realized by a Ta-absorber film of dimensions 450 μm $\times$ 160 μm which was read out at both ends by STJs, an energy resolution of 55 eV (FWHM) at 5.89 keV has been obtained in the central region [4].

References

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