TT 41: Focused Session: Cryogenic Detectors

Time: Thursday 15:00–17:30 Location: H 2053

Invited Talk TT 41.1 Thu 15:00 H 2053
Performance and Understanding of Transition-Edge Sensor Microcalorimeters — •Simon Bandler — NASA/Goddard Space Flight Center, Greenbelt, MD, USA — University of Maryland College Park, College Park, MD, USA

Microcalorimeters and bolometers incorporating Transition-Edge Sensor (TES) thermometers are achieving record-setting performance for a wide range of measurements ranging from microwave power to MeV-scale particles. TES thermometers consist of superconducting thin films electrically biased in the resistive transition. In this presentation I will describe recent results from a variety of different microcalorimeters designed for X-ray spectroscopic measurements in astrophysics and solar physics. These devices combine excellent energy sensitivity and high efficiency, can be fabricated in large numbers using lithographic techniques, and can be read out in large numbers using SQUID amplifiers. Despite the record-setting performance and growing utilization of the technology, a theoretical model of the physics governing TES devices' superconducting phase transition has until recently proven elusive. Our group at NASA has shown that TESs exhibit weak-link behavior, where, unlike previous models, the average strength of the order parameter varies over the TES. We find our TES measurements have a natural explanation in terms of a spatially varying order parameter. Implications of weak link behavior for microcalorimeter array design, performance and read-out are discussed.

Invited Talk TT 41.2 Thu 15:30 H 2053
Kinetic Inductance Detectors — •Jochem Baselmans — SRON Utrecht, The Netherlands

Microwave Kinetic Inductance Detectors, MKIDs, combine device simplicity, intrinsic multiplexing capability and a good sensitivity for radiation detection from the UV to the sub-mm part of the electromagnetic spectrum and for high energy particle detection. As a consequence MKIDs are now being developed in a plethora of varieties and for many different applications. Especially at Far Infra-Red-wavelengths band MKIDs offer the possibility to increase the size of detector arrays enormously, which if realized will undoubtedly revolutionize far-infrared astronomy. Arrays for the FIR currently reach photon noise limited performance and a high level of technological maturity, illustrated by the successful demonstration of increasingly large arrays at several ground based observatories such as the CSO, IRAM and APEX. I will address the fundamental limit in device performance, which is due to excess quasiparticle excitations at low bath temperatures $< T_c/10$ and possible mitigation strategies. I will also discuss recent progress in detector multiplexing: Using a single coax cable and one cryogenic microwave amplifier we can read out hundreds of pixels with photon noise limited performance.

15 min. break

Topical Talk TT 41.3 Thu 16:15 H 2053
Magnetic calorimeters for x-ray and particle detection — •Andreas Fleischmann — Universität Heidelberg, INF 227, 69120 Heidelberg,

Metallic magnetic calorimeters (MMC) are calorimetric particle detectors, typically operated at temperatures below 100 mK, that make use of a paramagnetic temperature sensor to transform the temperature rise upon the absorption of a particle in the detector into a measurable magnetic flux change in a dc-SQUID. During the last years a growing number of groups has started to develop MMC for a wide variety of applications, ranging from alpha-, beta- and gamma-spectrometry over the spatially resolved detection of accelerated molecule fragments to arrays of high resolution x-ray detectors. For soft x-rays an energy resolution of 2.0 eV (FWHM) has been demonstrated and we expect that this can be pushed below 1 eV in near future. We give an introduction to the physics of MMCs including the typically observed noise contributions and their impact on the energy resolution. We discuss general design considerations, the micro-fabrication of MMCs and the performance of micro-fabricated devices for a couple of applications.

Topical Talk TT 41.4 Thu 16:40 H 2053
Readout of TESs and MCCs with SQUID current sensors — •Jörn Beyer — Physikalisch-Technsiche Bundesanstalt Berlin

Transition-Edge Sensors (TESs) and Magnetically Coupled Calorimeters (MCCs) are two categories of low-temperature, low-impedance radiation detectors, that have the potential to significantly improve a variety of photon-sensing applications. For example, TES and MCC detectors and systems are under development to detect single THz photons, to enable the measurement of photon number states at telecom wavelengths with very high quantum efficiency or for high-resolution x ray and gamma ray spectrometers. Owing to their excellent sensitivity and dynamic performance as well as their compatibility with the low operating temperatures, current sensors based upon Superconducting Quantum Interference Devices (SQUIDs) are ubiquitously used to read out TESs and MCCs. The required SQUID performance in terms of input referred current noise, dynamic range, bandwidth, acceptable power dissipation and potential back-action can vary substantially for different TES or MCC detectors. Consequently, suitable SQUID current sensors need to be adapted to the readout configuration at hand. Ground- and satellite-based astronomy instruments that use thousands of TES pixels set particularly stringent requirements on the detector readout and require SQUID-based multiplexers. This contribution will review concepts and performance of state-of-the-art SQUID current sensors for single TES and MCC readout as well as SQUID multiplexing techniques.

Topical Talk TT 41.5 Thu 17:05 H 2053
Direct Dark Matter Search with the CRESST II Detector — •Jean-Côme Lanfranchi — Physik-Department E15, TU München, James-Franck-Strasse, 85748 Garching — Exzellenzcluster Universe, Boltzmannstrasse 2, 85748 Garching

CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) is an experiment aimed at the direct detection of Dark Matter. The experiment uses scintillating $CaWO_4$ single crystals operated at mK-temperatures to measure the recoil energy deposited by elastic WIMP (Weakly Interacting Massive Particle) nucleon scattering. By recording phonons as well as the associated scintillation light generated by an energy deposition in the crystal, CRESST is able to achieve a unique background suppression on an event-by-event level. In a two-year measuring campaign CRESST II has gathered ~ 730 kg days of data. In the analyzed data set an excess of events in the region of interest was observed and is at present difficult to explain with contributions from common backgrounds such as alpha-, beta-, gamma-radiation or neutrons. In a maximum likelihood analysis it could be demonstrated that these backgrounds alone are not sufficient to account for the number of events observed. However, the addition of a signal induced by a relatively light WIMP (10-30 GeV) could explain the observed discrepancy on a $\geq 4.2\ \sigma$ level. The associated parameters for such a Dark Matter particle will be discussed. The talk will conclude with an outlook on future efforts to pin down the nature of the observed events and on the low-temperature detector developments required to further reduce background.