TT 33: Superconductivity: Cryodedetectors & Cryotechnique

Time: Tuesday 14:00–15:30 Location: H19

TT 33.1 Tue 14:00 H19

Performance and readout of state-of-the-art MMC detector arrays — •M. Wegner, D. Hengstler, J. Geist, M. Keller, M. Krantz, C. Schötz, S. Kempf, L. Gastaldo, A. Fleischmann, and C. Enss — Kirchhoff-Institute for Physics, Heidelberg University

Metallic magnetic calorimeters (MMCs) are energy dispersive particle detectors which have a very good energy resolution, a large dynamic range as well as an excellent linearity. An MMC operates at millikelvin temperatures and converts the energy of an incoming particle into a rise of temperature of an absorber and an attached paramagnetic temperature sensor. The resulting change of sensor magnetization is read out by a SQUID and serves as a measure for the energy input.

One of our goals is the development of large detector arrays to provide a large detection area for low-rate applications, to cope with a significantly increased count rate or to provide imaging capabilities. For this, we have developed several medium-scale detector arrays which are optimized for x-rays up to 20, 30 and 200 keV, respectively. They have a resolving power $E/\Delta E$ above 1500 and are read out using individual dc-SQUIDs. To account for the readout of very large arrays with up to 1000 detectors, we develop a cryogenic frequency domain multiplexer which enables the readout of such large arrays using only one HEMT amplifier and two coaxial cables.

In this contribution we present our micro fabricated detector arrays and discuss their performance in the field of high resolution X-ray spectroscopy. In addition we show for the very first time a simultaneous readout of MMCs using our cryogenic multiplexer.

TT 33.2 Tue 14:15 H19

A 4k-pixel molecule camera for position and energy resolving detection of neutral molecular fragments — •Dennis Schulz[1], Andreas Fleischmann[1], Lisa Gamer[1], Loredana Gastaldo[1], Sebastian Kempf[1], Claude Krantz[2], Oldřich Novotný[2], Andreas Wolf[2], and Christian Enss[1] — [1]Kirchhoff Institute for Physics, Heidelberg — [2]Max Planck Institute for Nuclear Physics, Heidelberg

Stored beams of molecular ions at kinetic energies of some tens or hundreds of keV are widely used in molecular collision physics, and a mass spectroscopic identification of fragmentation products is often a key requirement for unambiguous data interpretation. For the reconstruction of the kinematics of electron-ion collisions at the Cryogenic Storage Ring (CSR, MPIK Heidelberg) we developed MOCCA, a new large-area 4096-pixel detector based on magnetic micro-calorimeters. Here, the kinetic energy deposited by a fragmented reaction product in one of the pixels is a measure of its mass, as all fragments have roughly the speed of the initial molecular ion. This calorimetric approach allows for identification of all fragments, in particular including neutrals. MOCCA has an active area of 45mm x 45mm, which is segmented into 64 x 64 absorbers, each 700μm x 700μm in size.

We discuss design considerations and present micro-fabricated detectors. We discuss the results of first tests with x-ray photons, including the uniformity of the detector response, cross-talk, multi-hit capability and the energy resolution for photons and for the massive particles. Including all effects, we expect MOCCA to easily resolve mass differences down to $1u$ for molecules with a few hundred mass units at CSR.

TT 33.3 Tue 14:30 H19

Low-frequency excess flux noise in superconducting devices — •Sebastian Kempf, Anna Ferring, Andreas Fleischmann, and Christian Enss — Kirchhoff-Institute for Physics, Heidelberg University, Heidelberg, Germany.

Low-frequency noise is a rather universal phenomenon and appears in physical, chemical, biological or even economical systems. However, there is often very little known about the underlying processes leading to its occurrence. In particular, the origin of low-frequency excess flux noise in superconducting devices has been an unresolved puzzle for many decades. Its existence limits, for example, the coherence time of superconducting quantum bits or makes high-precision measurements of low-frequency signals using SQUIDs rather challenging. Recent experiments suggest that low-frequency excess flux noise in Josephson junction based devices might be caused by the random reversal of interacting spins in surface layer oxides and in the superconductor-substrate interface. Even if it turns out to be generally correct, the underlying physical processes, i.e. the origin of these spins, their physical nature as well as the interaction mechanisms, have not been resolved so far.

In this contribution we discuss recent measurements of low-frequency SQUID noise which we performed to investigate the origin of low-frequency excess flux noise in superconducting devices. Within this context we give an overview of our measurement techniques and link our data with present theoretical models and literature data.

TT 33.4 Tue 14:45 H19

Fluorescence Measurements and Perspectives with Superconducting Tunneling Junctions (STJ) — •Ivan Baev[1], Jan-Hendrik Rüscher[1], Jens Viefhaus[2], Michael Martins[1], and Wilfried Wurth[1,2] — [1]Physics Department, University of Hamburg — [2]DESY Photon Science, Hamburg

The use of STJ's as absorber material for spectroscopic Soft X-Ray detection is very promising in terms of energy resolution and count rate capabilities. Because of the low excitation energy of Cooper pairs in a superconductor (few meV) three orders of magnitude more charge carriers than in a Si-detector are produced per photon. The ultimate resolution limit for such a detector is therefore in the order of a few eV instead of a few 100 eV in the soft X-ray regime. The first commercially available 36 pixel STJ detector is characterized and implemented into synchrotron radiation beamline operation. The achieved resolution is 10eV for 500 eV photons and 50eV for 1500eV photons with a maximal count rate of 10 kcps per pixel. This allowed for element specific Soft X-Ray fluorescence measurements at the P04 beamline at Petra III, DESY.

TT 33.5 Tue 15:00 H19

A large array of silicon microcalorimeters for storage ring experiments — •Saskia Kraft-Bermuth[1], Victor Andrianov[2], and Pascal Scholz[1] — [1]Justus-Liebig-Universität, Gießen, Germany — [2]Lomonosov Moscow State University, Moscow, Russia

Silicon microcalorimeters have already demonstrated the potential to considerably improve the experimental accuracy for X-ray experiments at heavy ion storage rings. To improve their performance with respect to statistical as well as systematic uncertainties, a large array of silicon microcalorimeters for high-precision X-ray spectroscopy, especially optimized for experiments at storage rings, has now been designed. In particular, the large dynamic range will allow the intrinsic determination of the Doppler correction, which is a prominent source of systematic uncertainty in such experiments. The contribution will present the design of the new detector array as well as the readout and data acquisition system. In addition, vibration studies of the cryogen-free dilution refrigerator will be presented.

TT 33.6 Tue 15:15 H19

Simulation of a new Compact Low-Noise Pulse Tube Cryocooler for Operation of Superconducting Optical Detectors near 5 K — •Bernd Schmidt[1,2], Matthias Vorholzer[1,2], Jens Falter[1], André Schirmeisen[1,2], and Günter Thummes[1,2] — [1]TransMIT-Center for Adaptive Cryotechnology and Sensors, Giessen, Germany — [2]Institute of Applied Physics, Justus-Liebig-University Giessen, Germany

The operation of superconducting optical sensors requires low-noise cooling techniques at temperatures down to 4-5 K, but only needs cooling powers well below 100 mW. Because of the rising l-He prices and even temporary shortage, cryogen-free cooling systems become more and more attractive. Among such dry cooling systems, PTCs, when compared to Stirling- and GM-cryocoolers, have an advantage due to the absence of a cold moving displacer. This unique feature leads to a low level of mechanical vibrations, lower EMI, and increased reliability of the cold head. While there are 4 K GM-type PTCs today that operate with a 2 kW helium-compressor and deliver a cooling power of about 250 mW at 4.2 K, we are developing an even smaller two-stage PTC within the framework of the BMBF joint project SUSY for cooling of bolometers and SNSPDs at temperatures near 5 K. The new PTC has an input power of less than 1 kW to reduce the intrinsic vibrations and improve the temperature stability. Numerical simulations of this new PTC show that it will, despite its small size and input power, still provide enough cooling power to operate the sensors.

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