TT 12: Symposium: Cryodetectors and SQUID

Time: Tuesday 9:30–12:45 Location: H 0104

Invited Talk TT 12.1 Tue 9:30 H 0104
SQUID multiplexers for low-temperature detectors — •K.D. Irwin, J.A. Beall, H.M. Cho, W.B. Doriese, W.D. Duncan, G.C. Hilton, R. Horansky, N. Jethava, J.A.B. Mates, C.D. Reintsema, D. Schmidt, J.N. Ullom, L.R. Vale, Y. Xu, and K. Yoon — National Institute of Standards and Technology, Boulder, Colorado 80305

The development of arrays of low-temperature detectors, including the superconducting transition-edge sensor (TES), has provided new capabilities for applications including astronomy, particle physics, and nuclear materials analysis. These applications require the implementation of large arrays of sensors. Due to constraints on cryogenic wiring heat load and complexity, it is impractical to route wires from room temperature to every pixel in a large low-temperature detector array. We have developed multiplexed readout circuits based on Superconducting Quantum Interference Devices (SQUIDs) to meet this need. We are implementing two SQUID multiplexer architectures: time-division multiplexed dc SQUID arrays operated at MHz frequencies, and frequency-division multiplexed rf SQUID arrays operated at microwave frequencies. Kilopixel TES arrays based on time-division multiplexed dc SQUIDs have reached maturity, and are being deployed in multiple instruments. Microwave frequency-division-multiplexed arrays of dissipationless rf SQUIDs coupled to superconducting microresonators have the promise of scaling to much larger array implementations in the future. The current status of these technologies, and future directions will be described.

Invited Talk TT 12.2 Tue 10:00 H 0104
Transition Edge Sensor and Kinetic Inductance Detector Developments for Astronomy Applications — •Piet de Korte — SRON Netherlands Institute for Space Research

Cryogenic radiation detectors enable significant progress in astronomy through the development of Imaging Spectrometers for X-ray astronomy based on micro-calorimeter arrays of Transition-Edge*Sensors, and through the development of highly sensitive, $< 10^{-19} W/Hz^{1/2}$, bolometer arrays for Infrared and Sub-mm astronomy. The latter application can be realized both by transion-edge-sensors as well as by kinetic inductance detectors. Both developments take place at SRON Netherlands Institute for Space Research for instruments on future missions, like XEUS (ESA) and SPICA (JAXA/ESA).

The presentation will explain the principles of both type of instruments, and show the present state of development both with regard to the sensor development as well as with regard to the read-out electronics.

TT 12.3 Tue 10:30 H 0104
Metallic magnetic calorimeters for high resolution x-ray spectroscopy and particle detection — •Loredana Fleischmann — Kirchhoff-Institut für Physik, Universität Heidelberg, INF 227, 69120 Heidelberg

An increasing number of experiments and applications employ low temperature particle detectors which are based on a calorimetric detection scheme and operated at temperatures below 100 mK. In many cases this is due to the high energy resolution achievable with these detectors. Equally important benefits are often the increased flexibility in the choice of absorber materials and the fact that the detection efficiency is independent of the ionizing character of the particles to be detected.

Metallic magnetic calorimeters (MMC) make use of a metallic paramagnetic temperature sensor, which is in tight thermal contact with an absorber for the particles of interest. The paramagnetic sensor is placed in a small magnetic field. Its magnetization is used to monitor the temperature, which in turn is related to the internal energy of the calorimeter. High energy resolution can be obtained by using a low-noise, high-bandwidth DC SQUID to measure the small change in magnetization upon the absorption of energy.

With recent x-ray detector prototypes an energy resolution of a few eV for x-ray energies up to 6 keV has been achieved. We discuss the thermodynamic properties, the energy resolution, the microfabrication and general design considerations of MMCs as well as their application in high resolution x-ray spectroscopy, beta spectroscopy and absolute activity measurements.

15 min. break

Prize Talk TT 12.4 Tue 11:15 H 0104
Methode zur berührungslosen, induktiven Messung der lokalen Übergangstemperatur supraleitender, dünner Wolframfilme — •Karoline Schäffner, Godehard Angloher, Irina Bavykina, Antonio Bento, Dieter Hauff, Patrick Huff, Michael Kiefer, Rafael Lang, Emilija Pantic, Federica Petricca, Franz Pröbst, Jens Schmaler, Wolfgang Seidel, Hans Seitz und Leo Stodolsky — Max-Planck-Institut für Physik, München — Trägerin des Georg-Simon-Ohm-Preises

Ziel des CRESST-Experimentes (Cryogenic Rare Event Search with Superconducting Thermometers) ist es, Dunkle Materie in Form von WIMPs direkt durch deren elastische Streuung an den Kernen eines Absorberkristalls nachzuweisen. Die Signalauslese der Teilchendetektoren erfolgt mit supraleitenden Phasenübergangsthermometern, welche aus dünnen Wolframfilmen bestehen.

Die supraleitende Übergangstemperatur von einkristallinem Wolfram liegt bei 15 mK. Die Übergangstemperatur dünner Wolframfilme kann jedoch durch Ausbildung einer metastabilen Beta-Phase, Filmspannungen oder Spuren von Verunreinigungen beeinflusst werden. Zur Untersuchung möglicher Inhomogenitäten dieser Filme wurde eine induktive Methode zur lokalen Messung der supraleitenden Übergangstemperatur entwickelt. Dabei wird eine Spule in geringem Abstand über einem Wolframfilm platziert. Die Änderung der Permeabilität des Wolframfilms beim Übergang in die supraleitende Phase führt zu einer Änderung der Induktivität der Spule, welche mit einem SQUID-basierten Messsystem nachgewiesen wird.

TT 12.5 Tue 11:45 H 0104
SQUID series array current sensor for measuring dc currents — •Jörn Beyer and Dietmar Drung — PTB, Berlin, Germany

Single SQUIDs are detectors of magnetic flux and show a multi-valued voltage-flux characteristics. In precision measurement systems they are used to sense changes in various physical quantities, e.g. magnetic field, electric current or mechanical displacement, which can be transformed into changes in the magnetic flux threading the SQUID loop. A dc-SQUID-based sensor able to detect a dc signal can be formed by a series array of individual dc-SQUIDs (SSA) with different loop sizes [1]. Due to the varying SQUID loop size such a SSA can per se not achieve a flux noise as low as of a same length SSA of identical SQUIDs. Here, we present a new SSA current sensor for measuring dc currents which comprises of identical individual SQUIDs. In this device, the input signal current is coupled tightly but non-uniformly to the individual array elements. This leads to a single-valued overall voltage-flux characteristics and, therefore, allows a dc input signal to be measured. Apart form the non-uniform input signal coupling the individual SQUIDs of the SSA current sensor can be flux-biased evenly, as well. This has a significant practical advantage as flux offsets equal in all the individual SQUIDs of the array can be compensated. Such flux offsets arise for instance due to asymmetric bias current feed into the array elements which is preferential for adjusting the dynamic resistance and therefore the noise performance. We present the design, simulations and experimental results on the dc-current sensor performance.

[1] P.Carelli et.al., Europhys.Lett. 39, 569 (1997)

TT 12.6 Tue 12:00 H 0104
Relaxationsmessungen mit SQUID Gradiometern — •Frank Schmidl, Markus Büttner, Christoph Becker, Alexander Steppke, Peter Kossebau, Stefan Prass und Paul Seidel — Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Germany

SQUID Gradiometer ermöglichen die Messung kleinster magnetischer Felder in unabgeschirmter Umgebung. Wir stellen Einsatzmöglichkeiten eines axialen SQUID Gradiometers zweiter Ordnung (Arbeitstemperatur 4,2 K) für Magnetorelaxationsmessungen an unterschiedlichen Nanopartikeln vor. Dabei kann das System zur Detektion der räumlichen Verteilung von magnetischen Nanopartikeln oder zur Untersuchung der Temperaturabhängikeit dieser Teilchensysteme genutzt werden. Letztere Untersuchungsmethode kann auf Grund des realisierten Temperaturbereichs von 4,2 K bis 320 K ein besseres Verständnis des Verhaltens dieser Materialsysteme liefern. Die aus dem experimentellen Aufbau resultierenden Möglichkeiten und Grenzen dieses Verfahrens für die Charakterisierung magnetischer Nanopartikle werden ebenso diskutiert, wie der mögliche Einsatz von Hochtemperatursupraleitern als Magnetfeldsensoren für derartige Anwendungen.

Die Arbeiten werden im Rahmen des EU-Projektes BIODIAGNOSTICS Nr.017002 gefördert.

TT 12.7 Tue 12:15 H 0104

Scanning THz-Microscopy of microwave devices with a Josephson-Cantilever — •Christian Brendel, Felix Stewing, and Meinhard Schilling — TU Braunschweig, Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, Hans-Sommer-Strasse 66, D-38106 Braunschweig, Germany

Microwave devices are operated at very high frequencies ranging up to the THz-regime. For characterization of transmission lines, filters and directional couplers at these very high frequencies new instruments are required. We present the set-up and applications of our scanning THz-electronics prober STEP. As scanning sensor we employ a Josephson junction from the high-temperature superconductor $YBa_2Cu_3O_7$ on a vibrating cantilever prepared from a $SrTiO_3$-bicrystal. This superconducting detector is cooled to a temperature of about 30 K by a cryocooler. Despite this low temperature of the cantilever, which is about 10 μm above its surface, the microwave device under investigation remains at room temperature. Based on this set up in a vacuum chamber we investigate the microwave properties of devices at frequencies of up to 768 GHz with a spatial resolution of 10 μm far below the corresponding wavelengths. For the higher frequencies we couple far-infrared laser radiation from a CO_2-laser pumped molecular laser system into the chamber. Applications of this novel instrument to microwave devices are demonstrated.

TT 12.8 Tue 12:30 H 0104

Highly sensitive and easy-to-use SQUID sensors — •Frank Ruede[1,2], Cornelia Assmann[1], Jörn Beyer[1], Dietmar Drung[1], Alexander Kirste[1], Margret Peters[1], and Thomas Schurig[1] — [1]PTB, Berlin, Germany — [2]Magnicon GbR, Hamburg, Germany

We have developed a family of low-noise superconducting quantum interference devices (SQUIDs) to cover a wide range of applications. These sensors are robust and easy to use without compromising noise performance. They are optimized for operation with the Magnicon high-speed flux-locked loop (FLL) electronics XXF-1.

This contribution focuses on SQUID current sensors with higher input inductances of up to 2μH. Typical applications for these sensors are the measurement of the magnetic field with a superconducting pickup loop connected to the input coil.

Dependent on the required noise level, single-stage and two-stage devices were realized in our latest sensor family 'C5'. The single-stage sensors achieve a coupled energy resolution around 70 times Planck's constant h at 4,2K and the two-stage sensor of 45h. They consist of a single front-end SQUID which is read out by a 16-SQUID series array. These sensors are very convenient to use as their voltage-flux characteristic is essentially single-SQUID-like. Devices optimized for low temperature operation achieve typically 4h at 300mK.

All sensor designs have an optional integrated current limiter (Q-spoiler) in series to the input coil, which can be used to reduce the current in pulsed applications like magnetorelaxometry.