TT 23 Solids At Low Temperature: Cryogenics

Time: Wednesday 14:30–16:15 Room: HSZ 02

Invited Talk

TT 23.1 Wed 14:30 HSZ 02

Electronic micro-refrigeration and thermometry — •Jukka Pekola[1], Alexander Savin[1], Matthias Meschke[1], Tero Heikkilä[1], Francesco Giazotto[2], Wiebke Guichard[3], and Frank Hekking[3] — [1]Low Temperature Laboratory, Helsinki University of Technology, P.O. Box 3500, 02015 HUT, Finland — [2]SNS, Pisa, Italy — [3]CNRS, Grenoble, France

Electronic thermometry is based on determining the energy distribution of electrons in a conductor. Refrigeration, in turn, is equivalent to narrowing this distribution. We discuss various relaxation mechanisms that determine the distribution under different experimental conditions. Particular devices to be described include thermometers based on Coulomb blockade, tunneling in hybrid tunnel junctions, interplay between thermal noise and shot noise, and refrigerators based on tunneling in normal-metal/superconductor and superconductor/superconductor tunnel junctions. Perspectives of miniaturized refrigerators between ambient and milli-kelvin temperatures are discussed. Observations of distributions beyond the equilibrium Fermi distribution will be reviewed as well. We conclude by a report of our recent observations of electron cooling by radiation through a superconducting line.

TT 23.2 Wed 15:00 HSZ 02

Low temperature confocal microscopy with a 4 K closed-cycle cryostat — •Christoph Boedefeld[1], Angelika Kueng[1], Christian Schulhauser[1], Matthias Buehler[2], and Jens Hoehne[2] — [1]attocube systems AG, Koeniginstrasse 11a (Rgb), 80539 Munich, Germany — [2]VeriCold Technologies GmbH, Bahnhofstrasse 21, 85737 Ismaning

Low temperature confocal microscopy is a technique of major interest with regard to research fields ranging from material and surface science to single molecule spectroscopy. Common setups involve the usage of expensive liquid helium and suffer from the lack of coarse positioning units at cryogenic temperatures. We present for the first time a highly flexible confocal microscope combined with a 4 K closed-cycle cryostat. This complete system solution enables plug-and-play high resolution confocal microscopy at low temperatures without the need of liquid helium. The low-vibration pulse tube based cryostat has been specially adapted for very low vibrations as required for applications in combination with scanning probe microscopy. Furthermore, extremely short cool down times of less than 2 hours for standard samples can be achieved. The developed confocal microscope is thermally compensated guaranteeing ultra-high stability at low temperature providing at the same time very high optical resolution as will be shown in various examples. Furthermore, nanopositioning units based on the slip-stick principle allow coarse positioning over centimeters. The system allows operation at extreme conditions as high magnetic fields and high vacuum.

TT 23.3 Wed 15:15 HSZ 02

Modified Closed Cycle Refrigerator for Neutron Diffraction Study at Temperatures around and below 1 K — •Bastian Klemke and Michael Meissner — BENSC, Hahn-Meitner Institut Berlin

A Joule-Thomson (J/T) Helium gas expansion stage has been designed to operate as a third stage attached to the second stage of a closed cycle refrigerator. Room temperature Helium gas (injection pressure p = 1...10 bar) is cooled by heat exchangers mounted to the cold heads of the first and the second stage, respectively. Inside the J/T unit the Helium gas is liquefied and simultaneously evaporated by an external rotary pump via an attached pumping tube. Using ^{4}He-gas results in a base temperature of 1.3 K and in a precise temperature regulation up to 50 K. Operation with ^{4}He-gas proved to be very simple and reliable as no gas handling system is needed. For closed loop circulation with ^{3}He-gas we set up a small gas handling system which operates with the same J/T unit. Base temperatures down to 0.6 K have been observed stable over long times and easy temperature regulation has been achieved, too. Because in neutron and x-ray scattering experiments sample change and cooling time from 300 K are an important issue, the J/T unit and heat exchangers have small thermal masses. Due to these construction details our present design can be operated in HUBER 5020 Euler cradles in all goniometer orientations.

TT 23.4 Wed 15:30 HSZ 02

Setup für in-situ ac-susceptibility measurements during neutron scattering at low temperatures — •Enrico Faulhaber[1], Oliver Stockert[2], and Michael Loewenhaupt[1] — [1]Institut für Festkörperphysik, TU Dresden, D-01062 Dresden — [2]Max-Planck-Institut für Chem. Physik fester Stoffe, D-01187 Dresden

Neutrons are a valuable microscopic probe to investigate magnetic ordering phenomena but are insensitive to superconductivity. Driven by our needs to directly correlate magnetism with superconductivity, we designed an in-situ ac-susceptibility setup for use in neutron scattering experiments at low temperatures. The setup follows the classical setup with one excitation coil and two pickup coils. The sample is placed beneath one pickup coil in the neutron beam to reduce the neutron background originating from scattering on the coils. Further, the coils were shielded against neutrons with boron nitride.

The setup has been used successfully in several experiments at the HMI in Berlin and at the ILL in Grenoble. Superconducting transitions could easily be traced. In addition, a recent experiment has shown that the setup is even able to detect magnetic ordering transitions. We will present the realised setup and selected results.

TT 23.5 Wed 15:45 HSZ 02

Thermally robust noise thermometer for milli-kelvin temperatures — •Astrid Netsch, Elena Hassinger, Christian Enss, and Andreas Fleischmann — Kirchhoff-Institut fuer Physik, Universitaet Heidelberg, INF 227, D-69210 Heidelberg, Germany

The temperature dependence of thermally driven voltage fluctuations of an electrical resistor is described by the dissipation-fluctuation theorem. This fundamental law of statistical physics provides a direct relation between temperature and independently measurable quantities, making the measurement of noise an attractive option for primary thermometry. However, the realization of such thermometers for the measurement of very low temperatures has often been problematic, preventing this technique from being widely used in low temperature laboratories. We present a setup for Johnson-noise thermometry that uses a commercial dc-SQUID as preamplifier. The noise to be measured is generated by the thermal motion of electrons in a bulk sample of a high purity metal such as gold or copper. These random currents cause fluctuations of magnetic flux in a pickup coil which is connected to the input coil of a current-sensor dc-SQUID. The thermometer is easy to fabricate and rather insensitive to typical sources of parasitic heating. We discuss general design considerations as well as the dependence of the temperature uncertainty upon measurement time. To characterize the thermometer we compared it to a superconducting standard reference device (SRD1000) which represents the temperature scale PLTS-2000. The spectral power density of flux noise was measured as a function of temperature and found to be linear in the investigated range from 6 mK to 4 K.

TT 23.6 Wed 16:00 HSZ 02

Low mechanical loss materials at cryogenic temperatures for interferometric gravitational wave detectors — •Anja Zimmer, Ronny Nawrodt, Sandor Nietzsche, Ralf Neubert, Matthias Thürk, Wolfgang Vodel, and Paul Seidel — Institut für Festkörperphysik, FSU Jena, Helmholtzweg 5, 07743 Jena

High precision instruments like gravitational wave detectors require components with very low thermal noise. This noise can be reduced by cooling down and using materials providing low mechanical loss even at the operating temperature. A special cryogenic measuring setup was used for investigation of the mechanical loss within the temperature range of 5 to 300 K. Experimental results on different materials are discussed focussing on microscopic processes in solids.

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