TT 28: Cryotechnique: Refrigeration and Thermometry

Time: Tuesday 11:15–12:45 Location: H23

TT 28.1 Tue 11:15 H23

A small scale 4 K pulse tube cryocooler suitable for geophysical measurements — •Bernd Schmidt[1,2], Jack Schmidt[1,2], Jens Falter[1], Günter Thummes[1,2], and André Schirmeisen[1,2] — [1]TransMIT-Center for Adaptive Cryotechnology and Sensors, Giessen, Germany — [2]Institute of Applied Physics, Justus-Liebig-University Giessen, Germany

Although pulse tube cryocoolers (PTCs) reaching liquid Helium temperature were already presented in the 1990s [1], they are still subject to vivid development in many directions. For instance, PTCs with cooling powers up to 2 W, capable of competing with large LHe cryostats, have been presented recently [2]. For such high cooling power, an input power of > 11 kW is needed. We here present a development in miniaturization of a small PTC providing 70 mW @ 4.2 K with low input power [3]. This PTC works with an air-cooled, single phase 1 kW Helium compressor and is suitable for sensitive low-temperature applications, such as SQUIDs, SNSPDs or TES. The working principle and design challanges of this cold head are discussed. The performance of cooling sensitive measurements is demonstrated with a proof-of-concept experiment of a dc SQUID in a geophysical setup [4].

[1] Wang, C., Thummes, G., et al. Cryogenics, 37, 159-164 (1997)
[2] Wang, C. A. , Cryocoolers, 19, 299-305 (2016)
[3] Schmidt, B., Vorholzer, M., Dietrich, M., Falter, J., Schirmeisen, A., & Thummes, G., Cryogenics, 88, 129-131 (2017)
[4] Schmidt, B., Falter, J., Schirmeisen, A., & Mück, M., Superconductor Science and Technology, 31, 075006 (2018)

TT 28.2 Tue 11:30 H23

Analysis of intrinsic variations of a small scale low input power 4 K pulse tube cryocooler driven by smart Helium compressor — •Jack-Andre Schmidt[1,2], Bernd Schmidt[1,2], Jens Falter[2], Stefano Spagna[3], Günter Thummes[1,2], and André Schirmeisen[1,2] — [1]Justus-Liebig-Universität Gießen — [2]TransMIT GmbH — [3]Quantum Design, inc.

Today's research often exceed the available measurement time with liquid helium cryostats. Closed cycle cryocooler offer the possibility of almost nonstop cooling around 4 Kelvin, but suffer from intrinsic temperature and mechanical variations due to their working principle with high and low pressure phases. Among the regenerative cryocoolers, pulse tube cold heads stand out because of the absence of moving parts at the cooled parts, which is a preferable choice for sensitive applications. Here we present an experimental study of the intrinsic effects of a minimized 4 K pulse tube [1]. For the first time a broad parameter set can be studied by using a smart energy compressor [2]. The results show potential aspects that should be considered to reduce intrinsic effects in future cryostat designs.

[1] Schmidt B., et al., Cryogenics 88 (2017) 129-131.
[2] Chialvo, C., et al., Proceedings of Cryocoolers 18 (2014).

TT 28.3 Tue 11:45 H23

Cross Correlated Noise Thermometer for Milli-Kelvin Temperatures — •Christian Ständer, Andreas Reifenberger, Felix Mücke, Marius Hempel, Sebastian Kempf, Andreas Reiser, Andreas Fleischmann, and Christian Enss — Kirchhoff-Institute for Physics, Heidelberg University.

Within our search for easy-to-use and reliable thermometers for milli-Kelvin and micro-Kelvin temperatures we developed a noise thermometer, where the Johnson noise of a massive cylinder of high purity silver is monitored simultaneously by two current sensing dc-SQUIDs. Operating both SQUIDs in voltage biased mode in a 2-stage configurations allows to reduce the power dissipation as well as the noise of the SQUIDs to a minimum. By cross-correlating the two SQUID signals, the noise contribution of the read-out electronics is suppressed to a marginal level even at micro-Kelvin temperatures. To further reduce the correlated amplifier noise we fabricated SQUIDs with minimal coupling of input and feedback coil. We compare two thermometers of this type to each other within the temperature range from 1 K down to 5 mK. Statistical uncertainties below 0.25 % are achieved within 10 s of measurement time. No significant systematic deviation between the two thermometers was observable. According to readout noise and a detailed thermal model the thermometers could be used down to 0.5 μK.

TT 28.4 Tue 12:00 H23

Measuring temperature gradients with superconducting sensors — •Sandra Sandra Gottwals[1], Thierry Crozes[2], and Georg Schmidt[1,3] — [1]Martin-Luther-Universität Halle-Wittenberg, Institut für Physik, Fachgruppe Nanostrukturierte Materialien, Halle — [2]Institut Néel, CNRS, Grenoble — [3]Martin-Luther-Universität Halle-Wittenberg, Interdisziplinäres Zentrum für Materialwissenschaften, Halle

For the investigation of spin caloric phenomena it is necessary to know the local temperature of the investigated material or even determine local temperature gradients. We intend to investigate the spin Nernst effect [1] in Pt which creates a spin Accumulation from a temperature gradient in a normal metal. Because we want to measure this spin accumulation using micro-SQUIDS [2] it is necessary to create and measure a temperature gradient over a distance of a few micrometer at cryogenic temperatures. The gradient is created by a resistive heater and the temperature gradient is determined using superconducting stripe sensors. The temperature dependence of the critical current in superconductors allows us to calibrate the sensors and to reliably measure the temperature. All structures are fabricated by e-beam lithography and reactive ion etching. We present details of the fabrication process and performance tests of individual sensors and sensor pairs.

[1] S.-G.Cheng, et al.: Phys. Rev. B 78 045302 (2008)
[2] W. Wernsdorfer: Supercond. Sci. Technol. 22 (2009) 064013

TT 28.5 Tue 12:15 H23

Crossover of dominant energy relaxation mechanism in normal metal films — •Libin Wang and Jukka Pekola — QTF Centre of Excellence, Department of Applied Physics, Aalto University, FI-00076 Aalto, Finland

For normal metals at low temperature, the electrons are known to be well decoupled from the phonons. When a constant heating is applied to the normal metal, the electron temperature will be elevated above the phonon temperature, which leads to the hot electron effect. For thin normal metal films at low temperature, the high thermal resistance (R_{ep}) between electrons and phonons in the metal films will dominate over the thermal boundary resistance (R_d) between the metal film and insulating substrate, and become the bottleneck for energy relaxation in the films. By increasing the film thickness or temperature, the ratio of R_{ep}/R_d will increase and to some point the dominant energy relaxation constrain will be the thermal boundary resistance between films phonons and substrate phonons. Here we will present the experimental observation of this crossover in normal metal films on the silicon substrate at temperature below 0.2K, where phonons in metal films are supposed to be two dimensional (2D). The derived thermal boundary resistance between 2D phonons and the substrate is a few times higher than that when the phonons are in the three dimensional (3D). The observed crossover for the dominant energy relaxation mechanism in normal metal films has significant benifit in understanding of thermal behavior of nanoelectronic devices at low temperature.

TT 28.6 Tue 12:30 H23

Development of a liquid hydrogen moderator with a free adjustable ortho/para ratio for the provision of specific cold neutron spectra — •Johannes Baggemann[1], Tobias Cronert[1], Ulrich Rücker[1], Paul Zakalek[1], Paul-Emmanuel Doege[1], Thomas Gutberlet[1], Sarah Boehm[2], Marcel Klaus[3], Sebastian Eisenhut[3], and Thomas Brückel[1] — [1]Forschungszentrum Jülich GmbH — [2]RWTH Aachen University — [3]TU Dresden

Neutron scattering as a method for studying structure and dynamics of condensed matter offers unique opportunities for a wide field of application. Under the frame of the High Brilliance Neutron Source (HBS) project, the Jülich Centre for Neutron Science is developing a new type of scalable accelerator driven pulsed neutron source. One of the projects objectives is to make the scattering method more accessible in regards to costs, lead times and restrictions. The design of the source enables an optimization along the whole neutron production chain towards the needs of each scattering experiment and fully offset the low neutron production.

One of the key components of this optimization is the development of a novel low dimensional liquid hydrogen neutron moderator with a variable ortho/para ratio. By adjusting this ratio, an optimal neutron energy spectrum could be delivered to a particular scattering experiment. After a brief introduction to the project, the fundamentals of the liquid ortho/para mixture as neutron moderator will be presented. The state of the development of the hydrogen moderator as well as its potential that must be determined experimentally will be outlined.