TT 49: Superconductivity: SQUIDs & Cryodetectors

Time: Wednesday 17:00–19:00 Location: H21

TT 49.1 Wed 17:00 H21

Dc SQUIDs with asymmetric shunt resistors — •Matthias Rudolph[1], Joachim Nagel[1], Johannes Maximilian Meckbach[2], Matthias Kemmler[1], Konstantin Ilin[2], Michael Siegel[2], Dieter Koelle[1], and Reinhold Kleiner[1] — [1]Physikalisches Institut - Experimentalphysik II and Center for Collective Quantum Phenomena in LISA$^+$,Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany — [2]Institut für Mikro- und Nanoelektronische Systeme, Karlsruhe Institute of Technology, Hertzstr. 16, D-76187 Karlsruhe, Germany

We have investigated asymmetrically shunted Nb/Al-AlO_x/Nb dc SQUIDs. Simulations based on the coupled Langevin equations predict that the optimum energy resolution ϵ, and thus also the noise performance of such an asymmetric SQUID, can be 3-4 times better than that of its symmetric counterpart. While keeping the total resistance R identical to a comparable symmetric SQUID with $R^{-1} = R_1^{-1} + R_2^{-1}$, we shunted only one of the two Josephson junctions with $R = R_{1,2}/2$. Both types of SQUIDs were characterized with respect to their transport and noise properties at temperature $T = 4.2\,K$, and we compared the experimental results with numerical simulations. Experiments yielded $\epsilon \approx 32\,\hbar$ for an asymmetric SQUID with an inductance $L = 22\,\mathrm{pH}$, whereas a comparable symmetric device achieved $\epsilon = 110\,\hbar$.

TT 49.2 Wed 17:15 H21

Nb nanoSQUIDs for detection of small spin systems — •R. Wölbing[1], J. Nagel[1], M. Kemmler[1], R. Kleiner[1], D. Koelle[1], O. Kieler[2], T. Weimann[2], J. Kohlmann[2], A. Zorin[2], A. Buchter[3], F. Xue[3], M. Poggio[3], D. Rüffer[4], E. Russo-Averchi[4], A. Fontcuberta i Morral[4], R. Huber[5], P. Berberich[5], and D. Grundler[4,5] — [1]Physikalisches Institut, Universität Tübingen, Germany — [2]Fachbereich 2.4 "Quantenelektronik", PTB Braunschweig, Germany — [3]Department of Physics, University of Basel, Switzerland — [4]Laboratoire des Matériaux Semiconducteurs, EPF Lausanne, Switzerland — [5]Physik-Department E10, Technische Universität München, Germany

We report on the realization of highly sensitive dc nanoSQUIDs for the investigation of small spin systems in moderate magnetic fields. The Nb SQUIDs are based on normal metal Josephson junctions made of HfTi and patterned by e-beam lithography. We demonstrate stable operation up to $B = \pm 50\,\mathrm{mT}$ without degradation of rms flux noise ($S_\Phi^{1/2} \leq 280\,\mathrm{n}\Phi_0/\sqrt{\mathrm{Hz}}$). We also present a multifunctional system combining a Nb nanoSQUID and a low-temperature magnetic force microscope (LTMFM) with a Ni nanotube as a scanning tip. This system allows for magnetization measurements of the Ni tube by using both, LTMFM and SQUID readout. Furthermore, the measurement of magnetic flux Φ vs. position of the particle provides an experimental determination of the coupling factor $\phi_\mu = \Phi/\mu$ between SQUID and Ni tube with magnetic moment μ. The results confirm our predictions from numerical simulations, taking into account the SQUID geometry.

TT 49.3 Wed 17:30 H21

Low-noise $YBa_2Cu_3O_7$ nanoSQUIDs for the detection of small spin systems operating in Tesla magnetic fields — •Tobias Schwarz, Joachim Nagel, Roman Wölbing, Reinhold Kleiner, and Dieter Koelle — Physikalisches Institut - Experimentalphysik II and Center for Collective Quantum Phenomena in LISA$^+$, Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

We investigated the noise performance of $YBa_2Cu_3O_7$ (YBCO) nanoSQUIDs with grain boundary Josephson junctions in high magnetic fields. On $SrTiO_3$ [001] bicrystal substrates YBCO films were grown by pulsed laser deposition and covered by an in-situ evaporated gold layer to provide non-hysteretic IV-curves. SQUIDs with line widths down to 100nm were fabricated by focused ion beam milling. A constriction next to the SQUID allows on-chip modulation of the magnetic flux coupled into the SQUID loop. The SQUID we present here can be operated in Tesla magnetic fields applied parallel to the SQUID loop. The white flux noise level increases only slightly from $S_\Phi^{1/2} = 1.3\,\mu_B/Hz^{1/2}$ at $B = 0$ to $S_\Phi^{1/2} = 2.3\,\mu\Phi_0\Phi_0/Hz^{1/2}$ at $B = 1\mathrm{T}$. Assuming that a point-like magnetic particle is placed on top of the constriction, we calculate a spin sensitivity $S_\mu^{1/2} = 62\,\mu_B/Hz^{1/2}$ at $B = 0$ and $S_\mu^{1/2} = 110\,\mu_B/Hz^{1/2}$ at $B = 1\mathrm{T}$. Further we show that by optimizing the parameters of the presented SQUID geometry spin sensitivities of a few $\mu_B/Hz^{1/2}$ should be feasible.

TT 49.4 Wed 17:45 H21

Experiments with Tunable Josephson Metamaterials — •Susanne Butz[1], Philipp Jung[1], Valery Koshelets[2], and Alexey V. Ustinov[1,3] — [1]Physikalisches Institut , Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — [2]Kotel'nikov Institute of Radio Engineering and Electronics RAS, Moscow 125009, Russia — [3]National University of Science and Technology MISIS, Moscow 119049, Russia

We will report on experiments investigating a tunable metamaterial consisting of rf-SQUIDs. A metamaterial is a medium constructed of artifical elements, so-called meta-atoms, that interact in a specific way with an incoming electromagnetic wave. The size of the individual meta-atom is much smaller than the wavelength. Our metamaterial consists of an array of rf-SQUIDs which is placed into a coplanar waveguide. The rf-SQUIDs couple to the magnetic field component of the propagating microwave. In a frequency range around the resonance frequency, the magnetic permeability μ_r of the metamaterial deviates strongly from the typical value of $\mu_r = 1$. By using an additional constant magnetic field bias, the inductance of the Josephson junction and thereby the resonance frequency of our meta-atom is changed. We show that the magnetic permeability of such a SQUID metamaterial is tunable in situ and compare the experimental results with numerical simulations.

TT 49.5 Wed 18:00 H21

MRX Measurement Setup Employing a Directly-Coupled High-T_c SQUID With Slotted Pickup Loop — •Alexander Guillaume, Frank Ludwig, Jan M. Scholtyssek, and Meinhard Schilling — Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, Technische Universität Braunschweig, Hans-Sommer-Str. 66, D-38106 Braunschweig, Germany

Magnetic nanoparticles (MNP) are employed in a wide range of medical and industrial applications. Besides other characterization techniques, magnetorelaxometry (MRX) is well established. In our MRX setup, we employ a directly-coupled high-T_c SQUID with a slotted pickup loop as magnetic field sensor.

The whole setup is installed in a magnetically shielded room. The MNP sample, which is attached to a glass dipstick containing the SQUID, is magnetized by a pair of Helmholtz-coils. In order to prevent flux vortices from entering the SQUID, the sensor is aligned parallel to the magnetizing field so that only the stray field of the MNP is measured. The aligning process is accomplished by using three alignment screws. Hence, the SQUID only measures 1 ppm of the magnetizing field which is in the order of several mT. Since the magnetic nanoparticles are placed in liquid nitrogen, the relaxation time constant increases in comparison to a measurement of the particles at room temperature allowing to investigate particle sizes down to 10 nm.

Here, we present our MRX setup and the employed SQUID design. We evaluate its performace by carrying out MRX measurements on immobilized MNPs.

TT 49.6 Wed 18:15 H21

AC susceptometry on the single-molecule magnet Ni_2Dy — •Pascal Wendler[1], Alexander Sundt[1], Amin Khan[2], Yanhua Lan[2], Annie K. Powell[2], and Oliver Waldmann[1] — [1]Physikalisches Institut, Universität Freiburg, Germany — [2]Institute of Inorganic Chemistry, Karlsruhe Institute of Technology, Germany

Molecular nanomagnets are molecules which show novel and fascinating magnetic properties. The best known phenomenon is the observation of magnetic hysteresis on the molecular scale in the single-molecule magnets (SMMs), such as Mn_{12}ac. In addition, quantum mechanical effects, such as the tunneling of the magnetization, can be observed in bulk samples of SMMs. A key goal for understanding the underlying physics is the measurement of the magnetization dynamics, which can be accomplished using ac susceptometry. However, the magnetic moments of samples of SMMs are weak since the volume density of the magnetic ions is very small as compared to e.g. inorganic compounds.

In this talk we will describe the construction of an ac susceptometer suitable for investigating molecular nanomagnets. A particular goal was to reach frequencies of the ac field of 100 kHz, extending the frequency range of commercial devices typically used in this research area by two decades. The device can be operated in the temperature range of 1.5 to 300 K and was characterized by comparing data recorded on Mn_{19} with available literature results. Lastly, we will present our experimental results on the novel SMM Ni_2Dy and discuss the different magnetic relaxation regimes observed in it.

TT 49.7 Wed 18:30 H21

Effect of the wire geometry and an externally applied magnetic field on the detection efficiency of superconducting nanowire single-photon detectors — •Robert Lusche[1], Alexey Semenov[1], Heinz-Willhelm Hübers[1], Konstantin Ilin[2], Michael Siegel[2], Yuliya Korneeva[3], Andrey Trifonov[3], Alexander Korneev[3], and Gregory Goltsman[3] — [1]DLR, Institut für Planetenforschung, Berlin, Germany — [2]Karlsruher Institut für Technologie — [3]Moscow State Pedagogical University, Russia

The interest in single-photon detectors in the near-infrared wavelength regime for applications, e.g. in quantum cryptography has immensely increased in the last years. Superconducting nanowire single-photon detectors (SNSPD) already show quite reasonable detection efficiencies in the NIR which can even be further improved. Novel theoretical approaches including vortex-assisted photon counting state that the detection efficiency in the long wavelength region can be enhanced by the detector geometry and an applied magnetic field. We will present spectral measurements in the wavelength range from 350-2500nm of the detection efficiency of meander-type TaN and NbN SNSPD with varying nanowire line width from 80 to 250nm. Due to the used experimental setup we can accurately normalize the measured spectra and are able to extract the intrinsic detection efficiency (IDE) of our detectors. The results clearly indicate an improvement of the IDE depending on the wire width according to the theoretic models. Furthermore we experimentally found that the smallest detectable photon-flux can be increased by applying a small magnetic field to the detectors.

TT 49.8 Wed 18:45 H21

maXs: Metallic Magnetic Calorimeters for High-Resolution X-ray Spectroscopy in Atomic Physics — •Daniel Hengstler[1], Sönke Schäfer[1], Christian Pies[1], Sebastian Kempf[1], Simon Uhl[1], Sebastian Heuser[1], Jeschua Geist[1], Nadine Foerster[1], Matthäus Krantz[1], Emil Pavlov[1], Sebastian Georgi[2], Thomas Wolf[1], Loredana Gastaldo[1], Andreas Fleischmann[1], and Christian Enss[1] — [1]Kirchhoff-Institut für Physik, Heidelberg — [2]Max-Planck-Institut für Kernphysik, Heidelberg

We are presently developing the detector array maXs, which will allow for benchmark experiments in x-ray spectroscopy to challenge bound-state QED calculations. maXs will consist of 32 Metallic Magnetic Calorimeters (MMCs), operated at temperatures around 30 mK in a dry $^3He/^4He$ dilution refrigerator. In such a MMC the energy of an absorbed photon leads to an increase of the detector temperature accompanied by a change in magnetization of a paramagnetic temperature sensor which is detected by a SQUID-magnetometer. One fourth of the detectors of the array will have an energy resolution of 3 eV for photon energies up to 20 keV. Three fourth of the detectors are designed for the detection of photons with energies up to 200 keV with a resolution of 40 eV. We discuss how to minimize the thermal and electromagnetic crosstalk between the detectors and how to remove the heat that is produced within the two-dimensional array without degrading the energy resolution. We consider how to ensure equal detector response despite a position-dependent absorption of high energy photons. Furthermore we present latest results of present prototype arrays.