TT 60: SC & MLT: Cryodetectors

Time: Friday 10:30–13:15 Location: HSZ 301

TT 60.1 Fri 10:30 HSZ 301

Ultra-thin TaN films for infrared Superconducting Nanowire Single-Photon Detectors — •Konstantin Ilin[1], Dagmar Rall[1,4], Matthias Hofherr[1], Michael Siegel[1,5], Alexei Semenov[2], Heinz-Wilhelm Hübers[2], Andreas Engel[3], Kevin Inderbitzin[3], Adrian Aeschbacher[3], and Andreas Schilling[3] — [1]IMS, Karlsuher Institut für Technologie, Karlsruhe, Deutschland — [2]DLR Institut für Planetenforschung, Berlin, Deutschland — [3]Physik-Institut der Universität Zürich, Zürich, Schweiz — [4]LTI, KIT, Karlsruhe, Deutschland — [5]DFG CFN, Karlsruhe, Deutschland

The quest for the development of superconducting nanowire single-photon detectors (SNSPD) with higher intrinsic detection efficiency in a wider spectral range stimulates the study of ultra-thin films of different superconducting materials. Tantalum nitride (TaN) is considered as a promising candidate for the development of SNSPDs for infra-red radiation. Thin superconducting TaN films were deposited by reactive magnetron sputtering from a pure Ta target in a gas mixture of Ar and N_2. The films were deposited on sapphire substrates heated to about 550 C. The transition temperature T_c of the thickest films (15 nm) was about 9.6 K. It decreased with the thickness remaining larger than 7 K for films with a thickness of 4 nm. SNSPDs made from TaN films have a critical current density of a few MA/cm^2 at 4.2K and T_c only slightly less than T_c of non-patterned films. Superconducting and normal state properties of micrometer and sub-micrometer sized TaN structures will be discussed in details. The single-photon response of TaN SNSPDs will be presented for the first time.

TT 60.2 Fri 10:45 HSZ 301

Microwave Kinetic Inductance Detectors for astronomy and particle detection — •Christian Hoffmann[1], Alessandro Monfardini[1], Markus Roesch[2], and Karl Schuster[2] — [1]Institut Néel, CNRS & Université J. Fourier, BP 166, 38042 Grenoble, France — [2]IRAM, 300 rue de la piscine, 38406 St. Martin d'Hères, France

A new type of superconducting detector, the Microwave Kinetic Inductance Detector, has recently drawn the attention of the low-temperature detector community. Easy fabrication, high sensitivity, low time constants and most notably the intrinsic capability to frequency multiplexing open new possibilities to applications that need very large array sizes and/or high speed read-out. We develop detector arrays for applications in the domain of astronomy, particle detection, phonon imaging and Helium-physics based on Lumped Element KIDs (LEKIDs). In a LEKID a resonant circuit composed of a discrete inductance and capacitance is coupled to a transmission line. The constant current density in the inductive part makes it a very efficient detector for em-radiation and particles. In this contribution we discuss detector principle, design and measured characteristics. Then we focus on the application for a millimeter wavelength camera, successfully tested at the IRAM 30-meter telescope at Pico Veleta, Spain in October 2010. The current instrument contains two arrays at 100 mK with more than 100 pixels on one read-out-line each for observations at 1.3 and 2 mm. The performances are the best achieved as of today for groundbased KIDs with sensitivities already comparable with existing (horns-coupled bolometers) instruments.

Invited Talk TT 60.3 Fri 11:00 HSZ 301

Engineering Atomic-Scale Spin Systems — •Sebastian Loth — IBM Research - Almaden, San Jose, CA

When magnetic structures shrink to a point where they consist of only a few atoms, their continuously variable magnetization transforms into a spin with quantized states. Their dynamical behavior is determined by the energetic distribution of these states. We demonstrate that low temperature scanning tunneling microscopy can access both the energetic and dynamical properties of electron spins in transition metal atoms that were placed on a Cu_2N overlayer on Cu(100).

Inelastic electron tunneling spectroscopy measures the transition energies of the atomic spins. Fe atoms experience large easy-axis anisotropy leading to a potentially bistable configuration, whereas Mn atoms in high magnetic field form a uniform ladder of spin states that is inherently unstable. The STM gains access to the corresponding dynamical evolution by all-electronic pump-probe spectroscopy. We measure the spin relaxation time of individual atoms or nanostructures with nanosecond precision and find that placing Cu atoms in decreasing distances to Fe atoms successively boosts the Fe atom's magnetic anisotropy energy and increases the spin relaxation time beyond 200 ns.

For potential spintronics applications, these experiments demonstrate the ability to manipulate the energetic structure of individual atomic spins and to directly monitor the resulting effect on the spin dynamics.

TT 60.4 Fri 11:30 HSZ 301

Cryogenic single-photon detector on the base of a S-I-N-I-S type single-electron trap — •Sergey V. Lotkhov[1], Antti Kemppinen[2], Olli-Pentti Siara[3], Jukka P. Pekola[3], and Alexander B. Zorin[1] — [1]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Brausnchweig — [2]Centre for Metrology and Accreditation (MIKES), P.O. Box 9, 02151 Espoo, Finland — [3]Low Temperature Laboratory, Aalto University, P.O. Box 13500, FI-00076 AALTO, Finland

For a long time, extremely high sensitivity of the single-electron circuits in respect to their electromagnetic environment was considered as a bottle neck for realization of a quantum current standard. For example, our recent experiments with the so-called hybrid superconductor-normal metal electron turnstiles on the base of Al and AuPd revealed an inherent relation of the pumping accuracy to the quality of noise filtering for such a device. In the current work, we generalize the task and regard our single-electron trapping circuit as a detector of single noise quanta, reaching the sample even in a well-filtered cryogenic setup at $T \sim 100$ mK. Owing to simplicity of the hybrid approach: our trap is built on a basic two-junction hybrid device controlled by a single gate, we can characterize not only the average noise level, but to conclude on the noise spectrum of the particular setup as well, on the frequency scale around $f \sim (E_c + \Delta)/h \sim$100-200 GHz, where E_c is the charging energy barrier in the trap, and Δ is a superconducting energy gap of Al.

15 min. break

TT 60.5 Fri 12:00 HSZ 301

Physics and Applications of Metallic Magnetic Calorimeters — •C. Pies, S. Heuser, A. Kampkötter, S. Kempf, J.-P. Porst, P. Ranitzsch, S. Schäfer, S. Vick, T. Wolf, L. Gastaldo, A. Fleischmann, and C. Enss — Kirchhoff-Institut für Physik, INF 227, 69120 Heidelberg

Metallic Magnetic Calorimeters (MMCs) are calorimetric particle detectors which are typically operated at temperatures below 100 mK. A paramagnetic sensor material is used to convert the temperature rise due to the absorbtion of a massive particle or photon to a change of magnetic flux which is detected by a SQUID magnetometer.

Since the thermodynamic properties of the detectors can be predicted with confidence, MMCs can be designed for specific applications with optimized performance concerning detection efficiency and energy resolution. Currently, an energy resolution of 2.7 eV (FWHM) for x-ray photons with energies of 6 keV has been achieved with fully micro-fabricated detectors and resolutions below 1 eV are expected for the next generation of devices. MMCs are being developed for a wide range of applications including x-ray spectroscopy of highly charged ions, direct neutrino mass measurements by beta spectroscopy, x-ray cameras for astronomy, calibration of radiation standards in metrology and spatially resolved detection of molecular fragments.

We present an introduction to the physics of MMCs and detector geometries for a variety of applications and discuss design considerations and micro-fabrication processes of current devices and their experimental performance.

TT 60.6 Fri 12:15 HSZ 301

Development of non-hysteretic unshunted rf-SQUIDs for multiplexed MMC readout — •S. Kempf, A. Fleischmann, L. Gastaldo, S. Heuser, A. Kampkötter, C. Pies, J.-P. Porst, P. Ranitzsch, S. Schäfer, S. Vick, T. Wolf, and C. Enss — Kirchhoff Institute for Physics, Heidelberg University.

Metallic magnetic calorimeters (MMCs) are energy dispersive particle detectors with a high resolving power that are operated at temperatures below 100 mK. Presently single channel MMCs are proving to be promising detectors in areas diverse as atomic and nuclear physics or x-ray astronomy, while many of those experiments would greatly benefit from large detector arrays. However, array readout poses a significant challenge since a multiplexing scheme is required. A promising approach employs a microwave SQUID multiplexer consisting of non-hysteretic unshunted rf-SQUIDs that are coupled to high Q tank circuits with unique resonance frequencies. By coupling all tank circuits to a common transmission line and injecting a microwave frequency comb it is possible to monitor all detectors simultaneously.

We discuss design, fabrication and operation of a microwave SQUID multiplexer for the readout of MMC detector arrays. For our present devices we used SNEAP to produce micron-size Nb/Al-AlO$_x$/Nb Josephson junctions with low critical current densities. The quality of the fabricated Josephson junctions is discussed. Finally we outline the expected performance of a detector array that is read out with the designed SQUID multiplexer as derived from numerical optimization calculations.

TT 60.7 Fri 12:30 HSZ 301

3D power distribution scan of Gaussian beams and THz-antennas — •Christian Brendel, Alexander Guillaume, 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

We imaged the three dimensional power distribution of far infrared Gaussian beams in the free space. Close to the beam waist we irradiated different THz antennas from below and scanned the radiation pattern in the 3D half space above the antennas. As scanning sensor we employ a Josephson-junction from the high-temperature superconductor $YBa_2Cu_3O_7$ on cantilever prepared from a $LaAlO_3$-bicrystal. The antenna on the Josephson-junction has to be smaller than the wavelength to achieve high spatial resolution but large enough to be able to detect sufficient power. Also the characteristic frequency, antenna impedance, bandwidth up to 1 THz and connection filters have to be optimized for a $LaAlO_3$-bicrystal substrate. The setup is mounted inside a vacuum chamber on x-, y- and z-tables with 15 mm scan length and is cooled down to a temperature of 38 K by a cryocooler. The measurement setup consists of a grating-tuned CO_2 laser (emission 9 - 11 μm) to pump a FIR laser with an output frequency range from 584 GHz up to 4.2 THz. We realized a quasi-optic THz-lens system to transfer the far infrared beam into the vacuum chamber.

We wish to acknowledge the financial support of C. Brendel by the Braunschweig International Graduate School of Metrology.

TT 60.8 Fri 12:45 HSZ 301

Coherent broadband THz spectrometer using photomixers in combination with magneto-cryostats: A compact solution for spectroscopy at low temperature and high magnetic field — •Komalavalli Thirunavukkuarasu[1], Andreas Janssen[1], Malte Langenbach[1], Holger Schmitz[1], Iván Cámara Mayorga[2], Rolf Güsten[2], Axel Roggenbuck[3], Anselm Deninger[3], Markus Grüninger[1], and Joachim Hemberger[1] — [1]II. Physikalisches Institut, Universität zu Köln, D-50937 Köln, Germany — [2]Max-Planck Institute for Radio Astronomy, Auf dem Hügel 69, D-53121 Bonn, Germany — [3]TOPTICA Photonics AG, Lochhamer Schlag 19, D-82166 Gräfelfing, Germany

We present the first results of the integration of a cw THz spectrometer together with magneto-cryostats for use at low temperatures and high magnetic fields. The high-resolution spectrometer employs photomixing of two NIR-DFB lasers for generation and phase sensitive detection of THz radiation in the frequency range from 60 GHz to 1.5 THz. A fiber-based phase modulation technique is used to accurately determine the amplitude and the phase at a given frequency. The complex optical functions can be evaluated from the full phase information of the THz beam. Recently, this compact spectrometer was successfully integrated within a magneto-cryostat. This system is one of the very few experimental realizations that allow for investigations at magnetic fields up to 16 T and temperatures down to 3 K with excellent reliability. The response of photomixers and the general operation of the spectrometer in these experimental conditions will be outlined.

TT 60.9 Fri 13:00 HSZ 301

Micro-Hall Magnetometer for Molecular Nanomagnets — •Alexander Sundt and Oliver Waldmann — Physikalisches Institut, Universität Freiburg, D-79104 Freiburg, Germany

In recent years the molecular nanomagnets (MNMs), e.g., the single-molecule magnets, have been the subject of many studies, as they exhibit phenomena such as magnetic hysteresis and quantum tunneling of the magnetization, which make them candidates for single molecule data storage devices and bits for quantum computing. To investigate this class of materials it is of apparent importance to measure their magnetization. The micro-Hall probes have been proven to be a highly sensitive and robust method in this direction. In this talk we will present the latest improvements of our in-house built magnetometer. The setup provides now an extended temperature range from 1.4 to 300 K and higher magnetic fields up to 7 T. However, the main improvements were to use: 1) novel micro-Hall sensors providing an increased sensitivity of up to 10^{-9} emu, 2) a double micro-Hall sensor configuration as well as a mimic, which allows for an in-situ adjustment of the orientation of the micro-Hall sensors to compensate for the main magnetic field, and 3) an improved scheme to measure light-induced magnetism in molecular clusters. The data recorded on several MNMs will be shown and discussed.