TT 36: Superconductivity: Cryodetectors

Time: Thursday 9:30–12:15 Location: H 2053

TT 36.1 Thu 9:30 H 2053

Superconductor-Insulator-Superconductor Mixer Devices for 1.1 THz — •Stefan Selig, Marc Peter Westig, Karl Jacobs, and Cornelia Honingh — I. Physikalisches Institut, Universität zu Köln

Superconducting frequency mixers are a crucial component of high spectral resolution heterodyne receivers for radio astronomy. Superconductor-Insulator-Superconductor (SIS) mixers are the established highest sensitivity choice in the submillimeter wavelength range. There is great interest in using SIS-mixers also for THz-frequencies since they offer a higher intermediate frequency bandwidth and potentially higher sensitivity and stability than superconducting hot electron bolometer mixers which are currently used in this regime.

A possible junction design for 1.1 THz would consist of a niobium-based SIS-junction embedded in NbTiN top and bottom wiring layers. It has been shown that such a junction exhibits strong DC heating effects due to quasiparticle trapping, the absence of diffusion cooling, and a slow electron-phonon interaction time. The heating substantially reduces the mixer performance. We investigate the possibility of adding a gold layer between the junction's Nb top electrode and the NbTiN top wiring in order to increase the heat transport coefficient. This and some additional challenges concerning the fabrication of these devices will be discussed in this talk.

TT 36.2 Thu 9:45 H 2053

Rückgeführte Referenzmessung von Magnetfeldfluktuationsthermometer — •Marco Schmidt[1], Jörn Beyer[1], Jost Engert[1], Sassan AliValiollahi[2] und Henry-Jobes Barthelmess[2] — [1]Physikalisch-Technische Bundesanstalt, 10587 Berlin, Abbestr. 2-12 — [2]Magnicon GmbH, 22397 Hamburg, Lemsahler Landstr. 171

Das Magnetfeldfluktuationsthermometer (MFFT) ist ein SQUID-basiertes, hochlineares Rauschthermometer für den Temperaturbereich von 1 mK bis 4 K. Das MFFT misst magnetisches Flussdichterauschen, das über einem Kupferkörper, dem eigentlichen Temperatursensor, von der thermisch angeregten Bewegung der Elektronen im Metall verursacht wird. Die Temperaturbestimmung erfolgt durch Analyse des Flussdichte-Rauschspektrums mit einem nichtlinearen Approximationsverfahren. Das MFFT ist ein einfach zu verwendendes Thermometer. Seine Anwendung erfordert jedoch eine einmalige Referenzmessung an einer bekannten Temperatur, die bisher vom Anwender durchzuführen ist. Mit dem Ziel, die Nutzung des MFFTs zu vereinfachen und seine Akzeptanz zu erweitern, wurde ein Tieftemperaturmessplatz für MFFT-Referenzmessungen aufgebaut. Supraleitenden Referenzpunkte (Cd, Zn, Al) deren Übergangstemperaturen auf die Temperaturskala PLTS-2000 rückgeführt sind, werden für die Realisierung der Referenztemperaturen verwendet. Mit dem neuen Messaufbau werden metrologisch-genaue MFFT-Referenzmessungen durchgeführt. Diese Messungen ermöglichen die Ermittlung der MFFT-Gesamtmessunsicherheit konform zum Guide to the expression of uncertainty in measurement (GUM).

TT 36.3 Thu 10:00 H 2053

Thin NbN film structures on SOI for SNSPD — •Konstantin Il'in[1], Stephan Kurz[1], Dagmar Henrich[1], Matthias Hofherr[1], Michael Siegel[1], Alexei Semenov[2], and Heinz-Wilhelm Huebers[2] — [1]IMS, KIT, Karlsruhe, Germany — [2]DLR, Berlin, Germany

Superconducting Nanowire Single-Photon Detectors (SNSPD) made from ultra-thin NbN films on sapphire demonstrate almost 100% intrinsic detection efficiency (DE). However the system DE values is less than 10% mostly limited by a very low absorptance of NbN films thinner than 5 nm. Integration of SNSPD in Si photonic circuit is a promising way to overcome this problem. We present results on optimization of technology of thin NbN film nanostructures on SOI (Silicon on Insulator) substrate used in Si photonics technology. Superconducting and normal state properties of these structures important for SNSPD development will be presented and discussed.

TT 36.4 Thu 10:15 H 2053

Influence of geometry on the critical current of superconducting nanowire single-photon detectors — •Dagmar Henrich[1], Patrick Reichensperger[1], Matthias Hofherr[1], Konstantin Il'in[1], Michael Siegel[1], Alexei Semenov[2], Heinz-Wilhelm Hübers[2,3], and Denis Vodolazov[4] — [1]IMS, Karlsruhe Institut für Technologie, Karlsruhe, Germany — [2]DLR, Berlin, Germany — [3]IOAP, Technische Universität Berlin, Berlin, Germany — [4]Nizhni Novgorod State University, Nizhni Novgorod, Russia

Superconducting Nanowire Single Photon Detectors (SNSPD) are made from thin superconducting films which are patterned into very narrow meander shaped lines. The current density distribution inside the nanowire, predicted by theory, shows an accumulation at the inner edges of such turns, which limits the total device critical current. Since the sensitivity of the SNSPDs as well as the spectral detection efficiency are strongly dependent on the factor of the local bias current to the critical current, the designs must be optimized to homogenize the current distribution. We experimentally investigate the influence of the angle and radius of curves on the critical current of nanowires. The samples are 300 nm wide nanowires made from ultra-thin NbN films deposited by DC reactive magnetron sputtering on 750°C heated sapphire substrates. Based on the results, we propose a design of an optimized detector layout for SNSPDs with homogeneous local detection efficiency.

TT 36.5 Thu 10:30 H 2053

Hot Spots and THz waves in single crystal $Bi_2Sr_2CaCu_2O_8$ mesas — •Boris Gross[1], Stefan Guenon[1], Matthias Gruenzweig[1], Jie Yuan[2], Mengyue Li[3], Zenguo Jiang[3], Yangyin Zhong[3], Akira Iishi[2], Peiheng Wu[3], Takeshi Hatano[2], Roman Mints[4], Dieter Koelle[1], Huabing Wang[2], and Reinhold Kleiner[1] — [1]PIT II, Universität Tübingen, Germany — [2]National Institute for Materials Science, Tsukuba, Japan — [3]Research Institute of Superconductor Electronics, Nanjing University, China — [4]Faculty of Exact Science, Tel Aviv University, Ramat Aviv, Israel

Josephson Junctions offer a natural way to convert a dc voltage into high-frequency electromagnetic (e.m.) radiation. Intrinsic Josephson junctions (IJJs) in $Bi_2Sr_2CaCu_2O_8$ (BSCCO) are very promising candidates to be used as devices in the THz regime, allowing frequencies up to 10 THz. Stacks of many hundred IJJs can be fabricated easily. Research on BSCCO THz generators stagnated in the past due to perhaps modest success in creating operating devices. In 2007 Ozyuzer et al. detected coherent radiation up to 0.85 THz from large, rectangular mesa structures on BSCCO single crystals, reviving the research in this field. More than 500 junctions in the stack oscillated in phase, leading to a power of up to 0.5 μW. The mesas are believed to work as a cavity for electromagnetic standing waves, synchronizing the junctions in the stack. We report on the investigation of heat distribution, e.m. standing waves and THz e.m. wave generation in BSCCO mesas, using a combination of transport measurements, direct e.m. wave detection and Low Temperature Scanning Laser Microscopy.

15 min. break.

TT 36.6 Thu 11:00 H 2053

Progress in the development of non-hysteretic rf-SQUIDs for a multiplexed MMC readout — •Sebastian Kempf, Andreas Fleischmann, Loredana Gastaldo, and Christian Enss — Kirchhoff-Institut für Physik, Universität Heidelberg.

Recently it was shown that the performance of single channel Metallic Magnetic Calorimeters (MMCs) meets the requirements of many applications like, for example, high resolution x-ray spectroscopy. Presently, a number of cryogenic multiplexing schemes are investigated to increase the channel count of MMC detector arrays significantly. A quite promising approach employs a so-called microwave SQUID multiplexer. Here, non-hysteretic unshunted rf-SQUIDs transduce the detector signals into a frequency shift of related superconducting microwave resonators with unique resonance frequencies. By injecting a microwave frequency comb and monitoring either phase or amplitude of each resonator, it is thus possible to infer the initial detector signals.

Based on experimental results obtained with our first prototype SQUID multiplexer and numerical simulations we optimized our current multiplexer design concerning rf-SQUID layout, SQUID-to-resonator coupling and fabrication of the Nb/Al-AlOx/Nb Josephson junctions. We discuss advantages of the modified fabrication process, differences between both multiplexer designs, the expected per-

formance improvements and present first measurements of this second generation SQUID multiplexer.

TT 36.7 Thu 11:15 H 2053

Metallic Magnetic Calorimeters for High-Resolution X-ray Spectroscopy in Atomic Physics — •S. Schäfer, C. Pies, S. Kempf, J.-P. P, S. Uhl, S. Heuser, T. Wolf, L. Gastaldo, A. Fleischmann, and C. Enss — Kirchhoff Institut für Physik, INF 227, 69120 Heidelberg

Highly-charged heavy ions are model systems for the investigation of quantum electrodynamical effects in strong electromagnetic fields.

We are developing x-ray detectors based on 1x8 arrays of Metallic Magnetic Calorimeters (MMCs) optimized for the spectroscopy of highly-charged ions at GSI/FAIR and the EBIT facility at the MPI for nuclear Physics in Heidelberg. One of the detector arrays (maXs-20) is designed to provide an energy resolution below 3 eV (FWHM) and sufficient stopping power for x-rays in the energy range up to 20 keV. The second device (maXs-200) is optimized for the detection of x-rays up to 200 keV and should yield an energy resolution below 30 eV (FWHM).

We present detector designs, outline the micro-fabrication process and discuss the results of characterization measurements with ^{55}Fe and ^{241}Am calibration sources including energy resolution, signal rise time and cross-talk between adjacent detectors of both arrays.

TT 36.8 Thu 11:30 H 2053

Neutron Scattering Facility for the Measurement of Light Quenching Factors of Low-Temperature Dark Matter Detectors — •Christian Ciemniak[1], Franz von Feilitzsch[1], Josef Jochum[2], Jean-Côme Lanfranchi[1], Walter Potzel[1], Raimund Strauss[1], and Stephan Wawoczny[1] — [1]Technische Universität München — [2]Eberhard-Karls-Universität Tübingen

Most direct dark matter search experiments aim at the detection of WIMPs (Weakly Interacting Massive Particles). To cover a large mass range, scintillating multi-material single crystals (e.g. $CaWO_4$, NaI, TeO_2) are of special interest. Operated as low-temperature detectors, each particle interaction produces a scintillation light and a phonon signal simultaneously in these crystals. Since the ratio of the two quantities depends on the type of particle interaction, it is possible to discriminate the electron and different types of nuclear recoils. The signal region for each type of interaction is quantified by the quenching factor (QF). At the Maier-Leibnitz Laboratorium in Garching, a dedicated neutron scattering facility has been set up to characterize scintillating multi-material target crystals and measure the bulk QFs of the different nuclei. A detector operated at mK temperatures is irradiated by mono-energetic neutrons ($\approx$ 11MeV). Both the phonon and the scintillation light signals are read out. The neutron's time of flight measurement at fixed scattering angle allows to identify the recoiling nucleus and to determine its QF.

TT 36.9 Thu 11:45 H 2053

Results of Light Quenching Factor Measurements of $CaWO_4$ at mK Temperatures for the Dark Matter Experiments CRESST and EURECA — •Raimund Strauss[1], Christian Ciemniak[1], Franz v. Feilitzsch[1], Josef Jochum[2], J.-C. Lanfranchi[1], Walter Potzel[1], and Stephan Wawoczny[1] — [1]Physik-Department E15, Technische Universität München, D-85747 Garching, Germany — [2]Eberhard-Karls-Universität Tübingen, D-72076 Tübingen, Germany

The CRESST and the future EURECA experiments aim at the direct detection of Cold Dark Matter (DM) with scintillating $CaWO_4$ crystals operated as cryogenic detectors at mK temperatures. DM particles such as the highly motivated Weakly Interacting Massive Particles (WIMPs) are expected to coherently scatter off nuclei and the corresponding nuclear recoils can be measured by the induced heat (phonon channel) and the corresponding scintillation light. Light Quenching Factors (QFs) quantify the individual reduction of the relative light yield for O, Ca and W recoils compared to electron recoils. The QFs of $CaWO_4$ are of utmost importance for the DM analysis as they allow a discrimination of backgrounds and - if a positive signal is observed - a WIMP mass-spectroscopy. Recently an extensive facility for the measurement of light QFs at mK temperatures via neutron scattering (time-of-flight) has been set up and successfully commissioned at the Maier-Leibnitz Laboratorium (MLL) in Garching. We present here first results for the QFs of $CaWO_4$ crystals at low temperatures.

TT 36.10 Thu 12:00 H 2053

Optimization of Cryogenic Light Detectors for the CRESST Experiment — •Anja Tanzke — MPI for Physics, Munich, Germany

The CRESST experiment aims to directly detect Dark Matter in the form of WIMPs. These hypothetical particles are expected to weakly interact via elastic scattering. The deposited energy is measured by the amplitude of the temperature pulse registered with a superconducting transition edge sensor on the scintillating target crystal. Additionally, the particle dependent scintillation light of the target crystal is detected by a cryogenic light detector. The performance of this detector is investigated and optimizations will be presented.