TT 31: Superconducting Electronics and Cryogenics: Poster Session

In case the presenters cannot be present at their posters for the full duration of the poster session, they are kindly requested to leave a note at their poster indicating when they will be available for discussion.

Time: Thursday 15:00–18:00 Location: P1

TT 31.1 Thu 15:00 P1

Modular architecture for circuit quantum electrodynamics — •Soeren Ihssen[1], Simon Geisert[1], Martin Spiecker[2], Patrick Paluch[2], Elie de Seze[1,3], Wolfgang Wernsdorfer[1,2], Patrick Winkel[4], and Ioan Pop[1,2] — [1]Institute for Quantum Materials and Technologies, KIT, Germany — [2]Physikalisches Institut, KIT, Germany — [3]ENS Paris-Saclay, France — [4]Yale University, USA

Superconducting quantum circuits play a pioneering role in finding a scalable architecture for the realization of a coherent quantum processor. In this context, keeping the integrity, individual addressability and controllability of each circuit component while increasing the complexity of the whole system is paramount to building a functional device. Fulfilling these key requirements becomes more difficult when increasing the connectivity in the circuit since parasitic cross-talk and the number of decay channels increase at the same time. Therefore, the coupling, readout and control mechanisms of every architecture need to be understood in great detail. Here, we investigate a flip-chip architecture in which we implement the readout and flux control of generalized flux qubits. With our approach, circuits serving different tasks within the system can be prepared individually and exchanged in case they do not fulfil the requirements. In our first realization, a bandpass Purcell filter for readout and an on-chip flux bias line are fabricated and tested regarding their microwave properties. The developed circuit enables a suitable easy-access framework for future experiments on qubit-qubit coupling in a well-controlled microwave environment.

TT 31.2 Thu 15:00 P1

Flip chip implementation for generalized flux qubits — •Simon Geisert[1], Sören Ihssen[1], Martin Spiecker[1,2], Patrick Paluch[1,2], Dennis Rieger[2], Simon Günzler[2], Elie De Seze[3], Wolfgang Wernsdorfer[1,2], Patrick Winkel[1,4], and Ioan Pop[1,2] — [1]Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology (KIT), Germany — [2]Physikalisches Institut, KIT, Germany — [3]ENS Paris-Saclay, France — [4]Yale University, USA

Superconducting flux qubits are a versatile and promising platform to implement coherent and tunable qubits with high anharmonicity. In this work, we investigate a generalized flux qubit consisting of a single Josephson junction (JJ) shunted by a capacitance and a granular aluminum inductor. When biased at the flux degeneracy point, the potential landscape can be widely engineered by exploring the parameter space of the flux qubit, which includes the loop inductance, the Josephson energy of the JJ and the total capacitance across the latter. We demonstrate a high engineerability of the qubit frequency, yielding flux qubits in the range of 150 MHz to 7.6 GHz. Dispersive readout of the qubit state is performed via an embedded harmonic mode that is inductively coupled through an asymmetry of the qubit loop. The readout mode is capacitively coupled to a control chip, which is used to excite, read out and flux bias the qubit. This flip chip approach allows very well isolated qubits to be tested in a modular architecture and enables coupling to two distinct coupler chips, effectively creating a unit cell that can be scaled up to an array of coupled qubits.

TT 31.3 Thu 15:00 P1

Simultaneous quantum jumps on multiple Fluxonium qubits — •Nicolas Gosling, Martin Spiecker, Patrick Paluch, Simon Geisert, and Ioan M Pop — Karlsruhe Institut of Technology

Superconducting quantum circuits have become one of the front runners for the implementation of scalable quantum processors. Hereby, the ability to design and implement multiple artificial atoms and their couplings has become an important task for many researchers. Therefore it is imperative to understand how events on one qubit influence other qubits on the same chip. Here, we take simultaneous quantum jump traces of multiple Fluxonium qubits on the same chip using a frequency multiplexed readout scheme through dispersive measurement. The simultaneity is ensured by the frequency multiplexing, enabling both signals to use the same input and output lines. The resulting quantum jump traces are then analysed for simultaneous events in respect to the stochastically expected coherences for perfectly uncoupled quantum systems.

TT 31.4 Thu 15:00 P1

Characterization of Josephson photonics devices as microwave sources for a quantum radar — •Lukas Danner[1,2], Ciprian Padurariu[2], Joachim Ankerhold[2], and Björn Kubala[1,2] — [1]Institute for Quantum Technologies, German Aerospace Center (DLR), Ulm, Germany — [2]ICQ and IQST, Ulm University, Ulm, Germany

In Josephson photonics devices, microwave radiation is created by inelastic Cooper pair tunneling across a dc-biased Josephson junction connected in-series with a microwave resonator [1]. Various resonances are accessed by tuning the dc-voltage, where, e.g., each tunneling Cooper pair creates one, two or three photonic excitations in the resonator. If excitations are created in two different resonators, the device could be used in a quantum radar which exploits the quantum correlations of the photons [2]. The source can be characterized by the steady-state Wigner density of the cavities, showing e.g. two-mode squeezing or other phase-space symmetries for multi-photon creation. Wigner-state tomography is expensive and in Josephson photonics devices especially challenging due to lacking phase stability. Therefore, we propose an alternative approximative characterization scheme which requires measuring only a few expectation values. A different way of dealing with the instability of the phase-space angle by a locking mechanism [3] is discussed in the contribution of F. Höhe.

[1] M. Hofheinz et al., Phys. Rev. Lett. 106, 217005 (2011)
[2] A. Peugeot et al., Phys. Rev. X 11, 031008 (2021)
[3] L. Danner et al., Phys. Rev. B 104, 054517 (2021)

TT 31.5 Thu 15:00 P1

Reflection-type superconducting microwave resonators for spin-based quantum memories — •Julian Franz[1,2], Patricia Oehrl[1,2], Manuel Müller[1,2], Thomas Luschmann[1,2,3], Rudolf Gross[1,2,3], and Hans Huebl[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Physik-Department, Technische Universität München, Garching, Germany — [3]Munich Center for Quantum Science and Technologies (MCQST), Munich, Germany

Solid-state spin ensembles are considered as excellent candidates for quantum memory applications due to their long coherence times and frequency compatibility with superconducting quantum circuits. The realization of such quantum memory requires the conversion of quantum microwave signals to excitations in the spin ensemble, their storage, and retrieval. This requires the detailed understanding and design optimization of the employed microwave circuit. The excitation transfer is typically measured by using a hanger type resonator. However, in a reflection-type geometry, all of the signal power is available for measurement, which gives nominally a factor of 2 improvement of the signal-to-noise ratio relative to the hanger configuration [1]. Here, we discuss the design concepts for superconducting microwave circuits with emphasis on tuning the coupling rates to the microwave circuit environment and the spin ensemble. In addition, we present experimental data using thin film NbTiN and Nb reflection-type resonators and characterize their performance at mK temperatures.

[1] H. Wang *et al.*, Quantum Sci. Technol., **6** (3), 035015 (2021)

TT 31.6 Thu 15:00 P1

MOCCA: A 4k-pixel molecule camera for the position and energy resolved detection of neutral molecule fragments — •Daniel Kreuzberger[1], Christian Enss[1], Andreas Fleischmann[1], Lisa Gamer[2], Loredana Gastaldo[1], Christopher Jakob[2], Ansgar Lowack[1], Oldřich Novotny[2], Andreas Reifenberger[1], Dennis Schulz[1], and Andreas Wolf[2] — [1]Heidelberg University — [2]Max Planck Institute for Nuclear Physics, Heidelberg

The MOCCA detector is a 4k-pixel high-resolution molecule camera based on metallic magnetic calorimeters and read out with SQUIDs that is able to detect neutral molecule fragments with keV kinetic energies. It will be deployed at the Cryogenic Storage Ring CSR at the

Max Planck Institute for Nuclear Physics in Heidelberg, a storage ring built to prepare and store molecular ions in their rotational and vibrational ground states, enabling studies on electron-ion interactions. To reconstruct the reaction kinematics, MOCCA measures the energy and position of incident particles on the detector, even with multiple particles hitting the detector simultaneously.

We present a new read-out scheme which uses only 32 SQUID channels for the 4096 pixels of the detector as well as some new fabrication details including a new thermalization system and first experimental results.

TT 31.7 Thu 15:00 P1

From ECHo-1k to ECHo-100k: Optimisation of the High-Resolution Metallic Magnetic Calorimeters with Embedded ^{163}Ho — •Markus Griedel[1], Arnulf Barth[1], Sebastian Berndt[2,3], Lorenzo Calza[1], Holger Dorrer[3], Christoph Düllmann[3,4,5], Christian Enss[1], Andreas Fleischmann[1], Daniel Hengstler[1], Tom Kieck[3,4,5], Nina Kneip[2], Neven Kovac[1], Federica Mantegazzini[1], Andreas Reifenberger[1], Alexander Karol Slawik[1], Klaus Wendt[2], and Loredana Gastaldo[1] — [1]Kirchhoff-Institute for Physics, Heidelberg University — [2]Institute of Physics, Johannes Gutenberg University Mainz — [3]Department of Chemistry - TRIGA Site, Johannes Gutenberg University Mainz — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH — [5]Helmholtz Institute Mainz

The ECHo collaboration aims to determine $m(\nu_e)$ by analysing the ^{163}Ho electron capture spectrum. Arrays of tens to hundreds of Metallic Magnetic Calorimeters (MMCs) implanted with ^{163}Ho have been chosen because of their excellent energy resolution in the range of a few eV, their fast response time below 1 μs and their good linearity. The MMC array enclosing ^{163}Ho fabricated for the ECHo-1k phase has been fully characterised in terms of detector response, energy resolution and ^{163}Ho activity. Based on these results a new 64-pixel-array design has been conceived for ECHo-100k, featuring an optimised single pixel geometry and allowing for a ^{163}Ho activity of 10 Bq per pixel. First wafers, each with 40 ECHo-100k chips, have been fabricated and characterised. The obtained results show that the ECHo-100k array achieved the expected performance, especially an average energy resolution of 3.5 eV, fulfilling the requirements for the ECHo-100k phase.

TT 31.8 Thu 15:00 P1

Towards large-area 256-pixel MMC arrays with multiplexed read-out based on flux-ramp modulated dc-SQUIDs — •A. Abeln, S. Allgeier, L. Eisenmann, D. Hengstler, N. Kahne, F. Krämer, D. Mazibrada, L. Münch, A. Stoll, A. Fleischmann, and C. Enss — Kirchhoff-institute for Physics, Heidelberg University

Metallic Magnetic Calorimeters (MMCs) are energy-dispersive cryogenic particle detectors. Operated at about 20 mK, they provide very good energy resolution of down to 1.6 eV at 6 keV, high quantum efficiency as well as linearity over a large energy range. In many precision based experiments on high resolution X-ray spectroscopy the photon flux is small, thus a large active detection area is desirable. Therefore, arrays with a large number of MMC pixels are beneficial. For a cost-effective read-out of a growing number of detector channels we develop different multiplexing techniques.

In this contribution we present the design of a novel 16 × 16 pixel MMC array. Each pixel provides an active detection area of 250 μm×250 μm yielding a total active detection area of about 4 mm × 4 mm. With a thickness of 5 μm the absorbers made of gold ensure a quantum efficiency of at least 50 % for energies up to 20 keV. The designed energy resolution according to numerical simulations is $\Delta E_{FWHM} = 1.4$ eV at an operation temperature of 20 mK. We also present the current status of flux-ramp multiplexing that allows to reduce the number of read-out channels by at least a factor of four compared to a conventional read-out.

TT 31.9 Thu 15:00 P1

PrimA-LTD: Magnetic microcalorimeters for primary activity standardization — •Michael Müller, Ria-Helen Zühlke, Peter Kähler, and Sebastian Kempf — Institute of Micro- and Nanoelectronic Systems, Karlsruhe Institute of Technology, Karlsruhe

Magnetic microcalorimeters (MMC) are cryogenic, energy-dispersive single-particle detectors that consist of a paramagnetic temperature sensor which is in strong thermal contact with a particle absorber. The sensor is magnetized by a magnetic field generated by a persistent current in an underlying superconducting pickup coil. The resulting change of sensor magnetization upon an energy input into the detector is read out by a SQUID. Due to their excellent energy resolution as well as the very low threshold, MMCs are a key technology in the frame of the EMPIR-project "PrimA-LTD" aiming to measure decay spectra of several isotopes with unprecedented precision to enable activity standardization for medicine and industry. Within this project we designed three MMC based layouts optimized for measuring the spectra of α-, β- and electron capture-decaying nuclides. We further developed a novel electroplating setup for the microfabrication of highly pure, 3D-structured particle absorbers made of Au to enable fast thermalization of the detector without position dependencies. Moreover, we started to develop a passive persistent current switch for injecting the persistent current allowing for easier detector handling and higher integration density in comparison to conventionally used heat switches. We summarize the present state of the project and outline ongoing next steps.

TT 31.10 Thu 15:00 P1

PrimA-LTD: Towards new primary activity standardization methods based on low-temperature detectors — •Alexander Göggelmann[1], Joern Beyer[2], Christian Enss[3,6], Sebastian Kempf[4,6], Karsten Kossert[1], Martin Loidl[5], Michael Müller[4], Ole Nähle[1], Michael Paulsen[2], Philipp Chung-On Ranitzsch[1], Matias Rodrigues[5], and Mathias Wegner[4,6] — [1]Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany — [2]Physikalisch-Technische Bundesanstalt (PTB), Berlin, Germany — [3]Kirchhoff-Institute for Physics, Heidelberg University, Germany — [4]Institute of Micro- and Nanoelectronic Systems, Karlsruhe Institute of Technology, Karlsruhe, Germany — [5]CEA, LIST, Laboratoire National Henri Bequerel, Saclay, France — [6]Institute for Data Processing and Electronics, Karlsruhe Institute of Technology, Karlsruhe, Germany

Radionuclide metrology, and in particular, activity standardization, is based on well-established measurement techniques that have been used and improved for decades. The methods and the achievable uncertainty are, however, very dependent on the type of radiation that is emitted and the quality of the available decay data. A major part of the EMPIR project "PrimA-LTD" consists in developing new primary techniques and in particular the high-resolution spectrometry of ^{241}Am, ^{129}I and ^{55}Fe using magnetic microcalorimeters (MMCs). The presentation will focus on the experimental details including the MMC detector setup, sample preparation and planned spectral measurements with more than 108 counts and energy thresholds below 50 eV.

TT 31.11 Thu 15:00 P1

Fabrication process for Nb/Al-AlO$_x$/Nb Josephson tunnel junction based SQUIDs for magnetic microcalorimeter readout — •Martin Neidig, Paul Kahrmann, and Sebastian Kempf — Institute of Micro- and Nanoelectronic Systems, Karlsruhe Institute of Technology, Karlsruhe, Germany

Magnetic microcalorimeters (MMCs) are cryogenic particle detectors providing an excellent energy resolution, very fast signal rise time, an almost ideal linear detector response and a large dynamic range. These properties combined with a maturing fabrication process motivate the implementation of large MMC based detector arrays which poses the challenge of developing a suitable readout method. Small-scale arrays are typically readout using single-channel dc-SQUIDs with individual wiring, while large-scale arrays require a multiplexed readout scheme. One such multiplexing scheme is the microwave SQUID multiplexer which allows for the readout of hundreds of detectors via a common feedline. The realization of either readout method requires the use of SQUIDs and therefore a reliable fabrication process for high quality Josephson junctions.

For this purpose we established a fabrication process for Nb/Al-AlO$_x$/Nb based window-type Josephson tunnel junctions. Within this contribution, we outline the present status of our fabrication technology and, moreover, we discuss the performance of the fabricated junctions and results of our prototype dc-SQUIDs, which are presently used for several MMC based experiments.

TT 31.12 Thu 15:00 P1

Noise Thermometers for Milli-Kelvin Measurements in High Magnetic Fields and for Micro-Kelvin Temperatures — •Pascal Willer, Christian Ständer, Nathalie Probst, Sarah Philips, Andreas Reiser, Andreas Fleischmann, and Christian Enss — Kirchhoff-Institute for Physics, Heidelberg University.

To measure the temperature in the presence of high magnetic fields is one of the big challenges in solid state physics labs. We recently

started to construct a prototype of a cross-correlated, current sensing noise thermometer for mK-temperatures for application in high magnetic fields. The basic concept relies on the thermal movement of charge carriers in a resistor. DC-SQUIDs detect the corresponding noise signal which is then recorded via two identical but independent amplifier chains. The method of cross correlation is used to eliminate uncorrelated noise contributions from the amplifier chains. As resistor material we use an alloy of platinum and thungsten, $Pt_{92}W_8$, since this material is characterized by an extremely small temperature dependence of the electrical resistivity as well as the smallest magnetoresistance known to date. We show that this approach towards a relative primary thermometer for high magnetic fields is able to operate over a wide range of temperatures within less than 1% uncertainty.
Additionally, we developed a second noise thermometer based on an alloy of copper and silver called "CuSil" to measure down to μK-temperatures in the absence of magnetic fields.
We discuss the design and the necessary considerations of both thermometers and present first experimental results at mK temperatures.

TT 31.13 Thu 15:00 P1

Microprocessor controlled temperature measurement with Allen-Bradley-carbon- and Platinum-100-Sensors — •Jelko Seiboth and Andreas Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum

This poster illustrates the setup of a device for the determination of temperatures between RT (294 K) and 4 K using Pt100 sensors and Allen-Bradley resistors with a RT value between 100 Ω and 1 kΩ. To measure the resistance, a Raspberry Pi with an analog-to-digital converter and upstream connected operational amplifiers is used. This combination provides a low price and easy further development.

The measurement is carried out with four-point technology, whereby, to reduce the temperature increase due to the electrical power consumed by the sensor, the supply of the Pt100 sensors is provided with constant current and that of the Allen-Bradley sensors with constant voltage. The device allows calibration for specific resistors and calculates the temperature from a polynomial fit function [1,2].

The determined value is shown on a display, recorded in a subsequently exportable file and output to a proportional connector with a voltage corresponding to the temperature. As the Raspberry Pi supports network connections via Ethernet and Wi-Fi, a remote retrieval or external database storage of the measurements may be implemented in the future. Calibration and temperature measurements were successfully taken to prove the functionality.

[1] B. Fellmuth, Guide to the Realization of the ITS-90. BIPM, 2018
[2] Star et al., J. Phys. [E] **2**, 257 (1969)

TT 31.14 Thu 15:00 P1

Characterization and optimization of different regenerator matrices on a single-stage pulse tube cryocooler — •Dominik Soare[1,2], Jack-André Schmidt[1,2], Bernd Schmidt[1,2], Jens Falter[2], and André Schirmeisen[1,2] — [1]Justus-Liebig University Giessen — [2]TransMIT GmbH

Closed-cycle cryocoolers have become an important cooling concept tool for scientific research at low temperatures [1]. We here focus on Gifford-McMahon (GM) type pulse tube cryocoolers (PTC), which offer long measurement periods and low maintenance. The regenerator of any regenerative cryocooler is essential for the cooling process [2]. The regenerator offers heat capacity as a storage for the gas temperature during the cooling cycle. It pre-cools or -heats the working gas and therefore the regenerator matrix is an important optimization factor.

The poster will display the influence of different regenerator matrices on the cooling performance of a single stage pulse tube cryocooler driven by a helium compressor with 2kW input power. Using the results, it is possible to get new insights of the optimization of the first stage of two-stage cryocoolers and therefore their overall cooling performance.

[1] R. Güsten et al., Nature 568 (2019) 357
[2] P. P. Steijaert, Thermodynamical aspects of pulse-tube refrigerators (1999) 10

TT 31.15 Thu 15:00 P1

Materials losses in superconducting circuits based on tantalum thin films — •Ritika Dhundhwal[1], Thomas Reisinger[1], Haoran Duan[2], Dirk Fuchs[1], Matthieu Le Tacon[1], Jasmin Aghassi-Hagmann[2], and Ioan M. Pop[1] — [1]Institut für Quantenmaterialien und technologien (IQMT), Karlsruher Institut für Technologie (KIT) — [2]Institut für Nanotechnologie (INT), Karlsruher Institut für Technologie (KIT)

Superconducting quantum circuits have very promising applications in the fields of quantum computing and detection. In general, their performance is limited by a variety of dissipation and noise sources. For mitigating these, the focus has been on improving microwave design and better fabrication processes. Another approach, recently in the spotlight, is to explore new materials entirely. One promising candidate superconducting material is Tantalum (Ta), which recently enabled record-breaking Transmon qubit lifetimes. However, there is a lack of conclusive evidence of the dominant loss mechanisms related to Ta. Here, we present a study of losses in epitaxial Ta films deposited using magnetron sputtering, with the aim of relating basic material properties and loss mechanisms. A variation in the deposition parameters (mainly substrate temperature) leads to structurally different films. We characterized these using high-resolution X-ray diffraction, scanning electron microscopy and measurements of the superconducting transition temperature. In addition, we fabricated lumped element resonators from the films using e-beam lithography and measured their quality factors as a function of photon number and temperature.

TT 31.16 Thu 15:00 P1

The Influence of Continuous Electric Bias Fields on the Dielectric Loss of Atomic Tunneling Systems — •Jan Blickberndt, Christian Ständer, Lukas Münch, Marcel Haas, Andreas Reiser, Andreas Fleischmann, and Christian Enss — Kirchhoff-Institute for Physics, Heidelberg, Germany

The low temperature properties of amorphous solids are mainly determined by atomic tunneling systems (TSs), which are known to act as a major source of noise and decoherence in superconducting quantum devices. We investigate the non-equilibrium dielectric loss of atomic tunneling systems under the influence of continuous electric bias fields at very low temperatures. By measuring the quality factor of a microfabricated superconducting resonator, the dielectric loss of the sample is obtained. Simultaneously, an electric bias field can be applied via a cover electrode, which allows us to sweep TSs through resonance by modulating their energy splitting. Experimentally, we found that for slow changing bias fields, TSs are saturated by the driving field leading to a constant loss. For faster bias rates, more and more TSs are swept through resonance and therefore contribute to an increasing loss. In the limit of fast continuous bias sweeps relaxation in between consecutive crossings diminishes and multiple coherent Landau-Zener transitions are possible, reducing the loss back to the saturation limit. We are able to verify these experimental results with a Monte Carlo based numerical simulation that shows good qualitative agreement.

TT 31.17 Thu 15:00 P1

Electrically and Acoustically Biased Resonators for Investigations of Dielectric Low Temperature Properties of Amorphous Solids — •Christian Ständer, Jan Blickberndt, Joyce Glass, Benedikt Frey, Andreas Reifenberger, Andreas Fleischmann, Andreas Reiser, and Christian Enss — Kirchhoff Institute for Physics, Heidelberg University, D-69120 Heidelberg

The low temperature properties of amorphous solids are governed by atomic tunnelling systems, which can be described as two-level systems (TLS) with a distribution of their energy splitting E, as assumed by the phenomenological standard tunnelling model. Recent interest in these systems due to their deteriorative effects on the performance of superconducting quantum devices lead to novel experimental investigations of atomic tunnelling systems driven by novel measurement techniques.
We use newly designed microfabricated superconducting LC-resonators to study the dielectric rf-response of the amorphous sample in the presence of an electric bias field. A novel method of applying this electrical bias field was introduced to the resonators. Compared to previous experiments, the bias field is applied via an electrode placed above the resonator chip. We present first results of this new way of introducing a bias, which modifies the energy splitting E of a TLS.
In addition we tried to achieve a similar effect as with the electrical bias field with a mechanical strain field. To induce such a strain field, the amorphous substrate of the resonator chip was flexed by a piezo-actuator.

TT 31.18 Thu 15:00 P1

Quantum electrodynamics of cold deposited granular aluminum — •Ameya Nambisan[1], Dennis Rieger[2], Simon Günzler[1], Wolfgang Wernsdorfer[1,2,3], and Ioan M Pop[1,2] — [1]Institute for Quantum Materials and Technology (IQMT), Karlsruhe Institute of

Technology (KIT), Germany — [2]Physikalisches Institut (PHI), Karlsruhe Institute of Technology (KIT), Germany — [3]Institute Néel, CNRS Grenoble, France

In recent times, superconducting granular aluminium (grAl) has found increasing interest in the superconducting quantum circuits community because of its promising characteristics such as its tunable kinetic inductance, low microwave losses, high in-plane critical magnetic field, and a higher critical temperature compared with pure Al.

In general, the critical temperature of a grAl film depends on its resistivity until it reaches a superconducting-to-insulator transition. For samples evaporated at room temperature, a maximum of around 2.2K is reached for resistivity of about 1000 $\mu\Omega$. The critical temperature rises even above 3K when grAl is deposited on a substrate held at a lower temperature of 100K.

This project aims to answer the question of increased Tc, which is yet to be understood microscopically, and other consequences of cold deposition, such as how a generally smaller – while more homogeneous – grain size positively affects the electrodynamics of the film. The testbed used to characterise the electrodynamics are stripline resonators fabricated entirely from cold-deposited grAl, and measured in a cylindrical copper waveguide sample holder at cryogenic temperatures.

TT 31.19 Thu 15:00 P1

Compact high-kinetic inductance using stacked Josephson junctions — •Alex S. Kreuzer[1], Thilo Krumrey[1], Hannes Rotzinger[1,2], and Alexey V. Ustinov[1,2] — [1]Physikalisches Institut (PHI), Karlsruher Institut für Technologie (KIT) — [2]Institut für Quantenmaterialien und -technologien (IQMT), Karlsruher Institut für Technologie (KIT)

Highly inductive elements are often required in modern superconducting quantum circuits, e.g. to form, together with a suitable capacitance, a large non-dissipative impedance. One way of creating such a high inductance is to employ series arrays of Josephson junctions, as it is done in the fluxonium qubit. For conventionally made chains of Josephson junctions, a major limitation arises from the stray capacitance of the islands forming the junctions. This capacitance leads to undesirable parasitic resonances at GHz frequencies, which degrade the quantum coherence of the qubit.

We propose a new way of creating high-inductance elements by stacking Josephson junctions vertically thus avoiding the influence of the through-substrate capacitive coupling of the junction electrodes to the environment. Furthermore, we demonstrate that our approach allows for making extremely compact circuit components.

TT 31.20 Thu 15:00 P1

Towards machine learning models for NISQ processors — •Andras Di Giovanni[1], Hannes Rotzinger[1,2], Alexey V. Ustinov[1,2], Adrian Aasen[3], Moritz Reh[3], and Martin Gärttner[3] — [1]Karlsruhe Institute for Technology, Karlsruhe, Germany — [2]Institut für QuantenMaterialien und Technologien, Karlsruhe, Germany — [3]Heidelberg University, Heidelberg, Germany

Quantum simulators promise insights into quantum many-body problems in regimes where classical simulation methods hit a complexity wall. One challenge towards this goal is to develop well characterized building blocks that allow to scale up system sizes while conserving reliability in terms of errors. A promising platform for building such NISQ (noisy, intermediate-scale quantum) devices are superconducting quantum circuits. Our goal is to characterize small scale quantum processors with minimal experimental and post-processing cost. For this we implement schemes for machine learning assisted adaptive Bayesian tomography and apply them to experimental data obtained from a prototype few-qubit superconducting chip.

TT 31.21 Thu 15:00 P1

Exploring the parameter regimes of superconducting Quarton qubits coupled via cross-Kerr nonlinearity — •Hossam Tohamy[1], Alex Siegfried Kreuzer[1], Thilo Krumrey[1], Hannes Rotzinger[1,2], and Alexey V. Ustinov[1,2] — [1]Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — [2]Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany

Over the last two decades, tremendous efforts have been directed into studying superconducting qubits as a promising architecture for noisy intermediate-scale quantum processors to implement quantum simulations and algorithms. A recent superconducting qubit named the "Quarton" represents a generalized flux qubit featured by a quartic potential profile. It can offer positive, strong cross-Kerr nonlinearity compared to the ordinary linear dispersive coupling between qubits and resonators. This nonlinearity can be essential, e.g., to achieve the next milestones in quantum simulation, such as the simulation of model Hamiltonians where strong photon-photon interactions are possible via nonlinear elements.

To employ the quarton as a qubit and a coupler, a system of two primary quarton qubits coupled via a quarton qubit coupler is studied. We report on numerical results demonstrating the normal modes of the system. The calculations are based on a Hamiltonian derived from a circuit quantization model. The work is linked to ongoing experimental efforts for realizing multiqubit architecture based on quartons.

TT 31.22 Thu 15:00 P1

Multilayer surface acoustic wave resonators at cryogenic temperatures — •Alexander Jung[1,2], Thomas Luschmann[1,2,3], Achim Marx[1], Rudolf Gross[1,2,3], and Hans Huebl[1,2,3] — [1]Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Physik-Department, Technische Universitaet Muenchen, Garching, Germany — [3]Munich Center for Quantum Science and Technologies (MCQST), Munich, Germany

Circuit quantum acoustodynamics uses the piezoelectric coupling of surface acoustic waves (SAW) to superconducting qubits for the implementation of concepts known from circuit quantum electrodynamics [1,2]. In this approach, the role of electromagnetic field is replaced by an acoustic wave propagating at the speed of sound. Moreover, the wavelength of acoustic waves is of the order of the size of the artificial atom, and thus their interaction with the qubit can no longer be treated pointlike. SAW resonators are an essential building block for quantum acoustodynamics. Of particular interest is the integration of SAWs using a piezoelectric on a silicon substrate to combine highly coherent qubits with excellent SAW properties. However, this changes the properties of the SAWs in particular for thin piezoelectric films. Here, we present simulations and experimental studies of SAW resonators fabricated on bulk and thin film piezoelectric substrates at cryogenic temperatures to understand the SAW as multilayer system.

[1] A.F.Kockum, International Symposium on Mathematics, Quantum Theory, and Cryptography (2021)
[2] Mathematics for Industry, 33, 125 (2020)

TT 31.23 Thu 15:00 P1

Flux-pumped Josephson Traveling Wave Parametric Amplifier — •Daniil E. Bazulin[1,2], Kedar E. Honasoge[1,2], Leon Koch[1,2], Yuki Nojiri[1,2], Thomas Luschmann[1,2], Achim Marx[1], Stefan Filipp[1,2,3], and Kirill G. Fedorov[1,2] — [1]Walther-Meißner-Institut, 85748 Garching, Germany — [2]Physik-Department, Technische Universität München, 85748 Garching, Germany — [3]Munich Center for Quantum Science and Technology (MCQST), 80799 Munich, Germany

Development of scalable superconducting quantum computers requires an efficient read-out of multiple quantum bits. This goal can be achieved by exploiting broadband Josephson Traveling Wave Parametric Amplifiers (JTWPAs). These are typically based on arrays of superconducting nonlinear elements, such as various types of Superconducting Quantum Interference Devices (SQUIDs). Here, we report on fabrication and characterization of a specific type of the JTWPA based on aluminium asymmetric SQUIDs exploiting the three-wave mixing down-conversion process. With this approach we circumvent inherent JTWPA problems with phase-matching and are able to spatially separate signal and pump paths.

TT 31.24 Thu 15:00 P1

Measurement of single NV centers inside a solid immersion lens at mK temperature — •Amer Hasecic, Ioannis Karapatzakis, Marcel Schrodin, Rainer Kraft, and Wolfgang Wernsdorfer — Physikalisches Institut, Karlsruher Institut für Technologie, Karlsruhe, Deutschland

A solid immersion lens (SIL) prevents refraction on a diamond-air surface and therefore increases the collection efficiency of detected photons [1]. SILs are nanofabricated by removing bulk material via focused ion beam technique. Here, we rely on accelerated gallium ions. The photon collection from single Nitrogen-Vacancy (NV) centers inside a solid immersion lens in bulk diamond is examined at mK temperatures. We aim to improve readout times for electron spin and nuclear spin states with the later being a promising system in quantum computing [2].

[1] M. Jamali, Rev. Sci. Instrum. 85, 123703 (2014)
[2] M. Abobeih, Nature (2022)

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Quantum manipulation of NV centers in diamond with on-chip coplanar waveguides at mK temperatures — •Ioannis Karapatzakis, Amer Hasecic, Marcel Schrodin, Rainer Kraft, and Wolfgang Wernsdorfer — Physikalisches Institut, Karlsruher Institut für Technologie, Karlsruhe, Deutschland

Quantum information technology is advancing in several physical fields. Optically addressable spins such as Nitrogen-Vacancy (NV) centers in the solid-state structure of diamond stand out for their versatile applications in quantum mechanics which range from quantum processing of information [1] to magnetic field sensing [2]. NV centers can be reliably initialized optically and have long coherence and relaxation times.

Here, the quantum manipulation of NV centers is shown inside a dilution refrigerator (sionludi) at mK temperatures. Using lithographically fabricated on-chip coplanar waveguide circuits, Rabi oscillations can be driven with frequencies above 100 MHz at comparatively low microwave insertion power of 100 mW (20 dBm). This allows for fast manipulation of the NV center spin states at mK temperatures without excessive heating of the sample.

[1] A. Tsukanov, Russian Microelectronics 41, 91 (2012)
[2] L. Rondin, Reports on Progress in Physics 77, 056503 (2014)

TT 31.26 Thu 15:00 P1

Navigation system for a low temperature STM — •Timo Kandra, Roman Hartmann, Marcel Strohmeier, Sara Khorshidian, and Elke Scheer — University of Konstanz, Germany

To obtain spatially resolved spectroscopic information in laterally confined superconducting heterostructures, such as nanowires and flakes on insulating substrates, tunneling spectroscopy on distinct locations on those structures shall be performed. For this purpose a coarse approach system is needed that allows to locate the STM tip at the point of interest without crashing the tip and while operating at very low temperature, here, 300 mK. We developed a braille-like pattern that allows to determine the absolute position of the tip within a 100x100 μm^2 scan range by scanning any area of size 1x1μm^2. The search structure made of gold is patterned by electron beam lithography and is realized by a topographical pattern composed of squares. With this method it is possible to navigate to the point of interest by using an xy-table.