TT 61: Superconductivity: Superconducting Electronics II and Cryotechnique

Time: Wednesday 15:00–16:45 Location: H 2053

Invited Talk TT 61.1 Wed 15:00 H 2053

Quantum Thermodynamics on Superconducting Qubits — •Jukka Pekola[1], Bayan Karimi[1], Alberto Ronzani[1], Jorden Senior[1], Yu-Cheng Chang[1,2,3], ChiiDong Chen[1,3], and Joonas Peltonen[1] — [1]Aalto University School of Science, Helsinki, Finland — [2]National Taiwan University, Taipei, Taiwan, Republic of China — [3]Academia Sinica, Taipei, Taiwan, Republic of China

I present quantum refrigerators based on superconducting qubits. In the theoretical part I describe a four-stroke Otto refrigerator, and a model of it in different operation regimes. Experiments on a transmon type qubit coupled to two resonators demonstrate heat transport, where the quantum-classical border is determined by the relative strength of qubit-resonator and resonator-heat bath couplings, respectively.

TT 61.2 Wed 15:30 H 2053

Bi-stability in a Mesoscopic Josephson Junction Array resonator — •Phani Raja Muppalla[1,2], Oscar Gargiulo[1,2], Mathieu Juan[1,2], Lukas grunehaupt[3], Gerhard Kirchmair[1,2], and Ioan Pop[3] — [1]Insitute for quantum optics and quntum information, technikerstrasse 21 A, Innsbruck- Austria — [2]university of innsbruck, innsbruck, Austri — [3]Karlsruhe Institute of Technology, Karlsruhe, Germany

We present an experimental analysis of the Kerr effect of extended plasma resonances in a mesoscopic Josephson junction (JJ) chain resonator inside a rectangular waveguide. The Kerr effect manifests itself as a frequency shift that depends linearly on the number of photons in a resonant mode. We study the bi-stable behavior, using a pump probe scheme on two modes of the JJ array, exploiting the Cross-Kerr effect in our system. In order to understand the behavior of the bi-stability we perform continuous time measurements to observe the switching between the two metastable states. We observe a strong dependence of the switching rates on the photon number and the drive frequency.

TT 61.3 Wed 15:45 H 2053

An on-demand source of anti-bunched microwave photons — •Florian Blanchet[1], Romain Albert[1], Salha Jebari[1], Alexander Grimm[2], and Max Hofheinz[1] — [1]Univ. Grenoble Alpes & CEA, INAC-PHELIQS, Grenoble, France — [2]Departement of Applied Physics, Yale University, New Haven, USA

Most superconducting devices use the Josephson junction in the zero-voltage branch where the junction behaves as a nonlinear inductor. However, Cooper pairs can tunnel through the Josephson junction also at non-zero bias voltage if the energy of a tunneling Cooper pair can be dissipated, e.g. in the form of photons [1]. By coupling the junction to a transmission line, we can detect these photons associated to inelastic Cooper pair tunneling [2] and measure their statistics.

In most configurations, the emitted photons have the same Poisson statistics as the tunneling Cooper pairs, corresponding to independent tunneling events. However, by designing particular high-impedance microwave circuits, we can tune the photon statistics to also be non-classical[3]. I will show that the photons emitted by such a circuit can be strongly anti-bunched.

In addition, we have replaced the Josephson junction by a SQUID which allows us to modulate the effective Josephson energy by applying magnetic flux pulses. We use these pulses to generate anti-bunched photons on demand up to rates > 150 MHz.

[1] PRL 73, 3455 (1994)
[2] PRL 106, 217005 (2011)
[3] PRL 115, 027004 (2015)

TT 61.4 Wed 16:00 H 2053

Green's function approach to normal-metal quasiparticel traps — •Raphael Schmit and Frank Wilhelm-Mauch — Theoretical Physics Department, Saarland University, 66123, Saarbrücken, Germany

Decoherence mechanisms affect the storage of quantum information. Origin are e.g. usually unwanted interactions between the qubit and its environment. In the case of superconducting qubits, additional decoherence comes from the coupling between the qubit's degree of freedom and the non-equilibrium quasiparticle (QPs) excitations in the superconductor the qubit is made of. The underlying mechanism – mainly QP tunneling through a Josephson junction – is highly dependent on the location of the QPs: Those far away from junctions have much less contribution to decoherence than the ones close to it. While their generation is difficult to prevent, trapping them in less active regions of the device provide a practicable way to improve the device performance.

The performance of normal-metal QP traps simply consisting of a normal metal island which is in contact with the superconductor, can be investigated by a voltage biased NISN juntion. We are applying a Green's function formalism – the Keldysh technique in the dirty limit with a quasiclassical approximation – to investigate the properties of the non-equilibrium QPs in the junction. Physical quantities like the order parameter, the QP density of states or their density are accessible via the self-consistent solutions of the Usadel equations that are computed numerically.

TT 61.5 Wed 16:15 H 2053

Quantum information in heat engines — •Mohammad Ansari[1] and Yuli Nazarov[2] — [1]Forschungszentrum Juelich, Juelich, Germany — [2]Delft University of Technology, Delft, Netherlands

We present a universal relation between the flow of a Renyi entropy and the full counting statistics of energy transfers. We prove the exact relation for a flow to a system in thermal equilibrium that is weakly coupled to an arbitrary time-dependent and nonequilibrium system. The exact correspondence, given by this relation, provides a simple protocol to quantify the flows of Shannon and Renyi entropies from the measurements of energy transfer statistics. This finds interesting applications in superconducting quantum bits, photocells, photosynthesis, and other quantum heat engines.

[1] M. H. Ansari, Y. V. Nazarov, Phys. Rev. B 91, 104303, (2015).
[2] M. H. Ansari, Y. V. Nazarov, Phys. Rev. B 91, 174307, (2015).
[3] M. H. Ansari, Y. V. Nazarov, J. Exp. Theor. Phys. 122, 389, (2016).
[4] M. H. Ansari, Phys. Rev. B 95, 174302, (2017).

TT 61.6 Wed 16:30 H 2053

A small two-stage PTC operating at liquid Helium temperature with 1 kW input power — •Bernd Schmidt[1,2], Matthias Vorholzer[2], Marc Dietrich[1], 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

Cryocoolers provide temperatures of less than 4 K without the need of liquid Helium. Additionally, the Pulse Tube Cryocooler (PTC) has has no moving parts in the cold part, which leads to lower disturbances.

Many developments of PTCs aim for higher cooling power at 4.2 K (> 1.5 W). However, some applications only need small cooling powers (< 100 mW), but suffer from the intrinsic disturbances of cryocoolers.

In this talk we present a new two-stage GM-type PTC, driven by a commercial Helium compressor with only 1 kW input power. The PTC reaches a minimum temperature of 2.36 K and provides a cooling power of 72 mW at 4.2 K. (1) It was initially designed to cool down SNSPDs and transition-edge bolometers. First measurements with low-noise Nb-SQUIDs were already made. Since the PTC can be easily driven by a portable generator, it is also suitable e.g. for in-field measurements like geophysical studies.

Funding via the BMBF joint project "SUSY" (grant No 13N13444) is gratefully acknowledged.

[1] Cryogenics 88 (2017) 129