TT 75: Superconductivity: Mesoscopic Superconductivity and Quantum Circuits

Time: Wednesday 17:00–18:30 Location: H 2053

TT 75.1 Wed 17:00 H 2053

Reducing phase drift by injection locking a cavity mode driven by a Josephson junction — •Ciprian Padurariu, Björn Kubala, and Joachim Ankerhold — Institute for Complex Quantum Systems and IQST, Ulm University, 89069 Ulm, Germany

Circuit QED devices are highly tunable radiation emitters with high photon collection efficiency, leading as candidates for on-demand single photon sources, on-demand entangled photon pairs, and sensitive single photon detectors in the microwave spectrum [1]. The main hurdle on the way to full quantum control of the emitted radiation is phase drift due to electrical noises generated from outside, as well as from within, the device [2].

In quantum optics, a well known technique to reduce phase drift is injection locking to a low intensity, narrow bandwidth laser. We borrow this technique for circuit QED by locking the active mode to a small amplitude near-resonant microwave tone. We describe theoretically the quantum dynamics of injection locking and quantify the effectiveness of the phase drift reduction. When the microwave tone is off-resonant, we describe the phenomenon of frequency pulling, where the frequency of radiation emission is shifted towards that of the microwave tone.

[1] M. Westig *et al*, Phys. Rev. Lett. **119**, 137001 (2017).
[2] S. Dambach *et al*, New J. Phys. **19**, 023027 (2017).

TT 75.2 Wed 17:15 H 2053

Noise switching at a dynamical critical point in a cavity-conductor hybrid — Andrew D. Armour[1], •Björn Kubala[2], and Joachim Ankerhold[2] — [1]School of Physics and Astronomy and Centre for the Mathematics and Theoretical Physics of Quantum Non-Equilibrium Systems, University of Nottingham, Nottingham NG7 2RD, UK — [2]Institute for Complex Quantum Systems and IQST, Ulm University, Albert Einstein-Allee 11, 89069 Ulm, Germany

Coupling a mesoscopic conductor to a microwave cavity can lead to fascinating feedback effects which generate strong correlations between the dynamics of photons and charges. We explore the connection between cavity dynamics and charge transport in a model system consisting of a voltage-biased Josephson junction embedded in a high-Q cavity, focussing on the behavior as the system is tuned through a dynamical critical point. On one side of the critical point the noise is strongly suppressed, signalling the existence of a novel regime of highly coherent transport, but on the other side it switches abruptly to a much larger value. Using a semiclassical approach we show that this behavior arises because of the strongly nonlinear cavity drive generated by the Cooper pairs. We also uncover an equivalence between charge and photonic current noise in the system which opens up a route to detecting the critical behavior through straightforward microwave measurements.

TT 75.3 Wed 17:30 H 2053

Adiabatic Simulation of the Hydrogen Molecule with Superconducting Qubits — •Marco Roth[1], Marc Ganzhorn[2], Nikolaj Moll[2], Stefan Filipp[2], Gian Salis[2], and Sebastian Schmidt[3] — [1]Institute for Quantum Information, RWTH Aachen University, D-52056 Aachen, Germany — [2]IBM Research - Zurich, Zürich, Switzerland — [3]Institute for Theoretical Physics, ETH Zürich, Switzerland

Superconducting circuits are well suited for the adiabatic simulation of Hamiltonians with bosonic as well as fermionic degrees of freedom. Here, we present analytical and numerical results, which demonstrate the feasibility of simulating the groundstate of the hydrogen molecule using two superconducting qubits. In our proposal tunable two-qubit interactions are realised by parametrically modulating the frequency of a tunable bus element with an external magnetic flux. We derive the effective Hamiltonian of the device with tunable XX and YY type interactions using a time-dependent Schrieffer-Wolff transformation. Numerical simulations of a quantum annealing protocol for the groundstate of the hydrogen molecule demonstrate that the time required to reach chemical accuracy lies in the few microsecond range for typical device coherence.

TT 75.4 Wed 17:45 H 2053

A passive on-chip, superconducting circulator using a ring of tunnel junctions — •Clemens Müller[1], Shengwei Guan[1], Nicolas Vogt[2], Jared H. Cole[2], and Thomas M. Stace[1] — [1]ARC Centre of Excellence for Engineered Quantum Systems, The University of Queensland, Brisbane, Australia — [2]Chemical and Quantum Physics, RMIT University, Melbourne, Australia

We present the design of a passive, on-chip microwave circulator based on a ring of superconducting tunnel junctions. We investigate two distinct physical realisations, based on either Josephson junctions (JJ) or quantum phase slip elements (QPS), with microwave ports coupled either capacitively (JJ) or inductively (QPS) to the ring structure. A constant bias applied to the center of the ring provides the symmetry breaking (effective) magnetic field, and no microwave or rf bias is required. We find that this design offers high isolation even when taking into account fabrication imperfections and environmentally induced bias perturbations and find a bandwidth in excess of 500 MHz for realistic device parameters.

TT 75.5 Wed 18:00 H 2053

Semiclassical quantisation of spinning quasiparticles in ballistic Josephson Junctions — •Sebastian Bergeret[1], Ilya Tokatly[2], and François Konschelle[1] — [1]Material Phsyics Center (CSIC) , San Sebastian — [2]Universidad del Pais Vasco

A Josephson junction made of a generic magnetic material sandwiched between two conventional superconductors is studied in the ballistic semiclassic limit. The spectrum of Andreev bound states is obtained from the single valuedness of a particle-hole spinor over closed orbits generated by electron-hole reflections at the interfaces between superconducting and normal materials. The semiclassical quantization condition is shown to depend only on the angle mismatch between initial and final spin directions along such closed trajectories. For the demonstration, an Andreev-Wilson loop in the composite position* particle-hole*spin space is constructed and shown to depend on only two parameters, namely, a magnetic phase shift and a local precession axis for the spin. The details of the Andreev-Wilson loop can be extracted via measuring the spin-resolved density of states. A Josephson junction can thus be viewed as an analog computer of closed-path-ordered exponentials.

[1] Phys. Rev. Lett. 116, 237002 (2016)
[2] Phys. Rev. B. 94, 014515 (2016).

TT 75.6 Wed 18:15 H 2053

Spectroscopy of Two-Level-Systems in an Xmon Qubit — •Alexander Bilmes[1], Georg Weiss[1], Alexey V. Ustinov[1,2], and Jürgen Lisenfeld[1] — [1]Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — [2]Russian Quantum Center, National University of Science and Technology MISIS, Moscow 119049, Russia

Superconducting quantum circuits are close to fulfilling all criteria to realize a quantum processor. However, a severe coherence-limiting factor are Two-Level-Systems (TLS) that reside in substrate-qubit interfaces or dielectric layers such as surface oxides and the tunnel barrier of the Josephson junction. Since TLS possess an electrical dipole moment, they can couple to the oscillating field of the qubit's circuit, making them an energy sink for the qubit. We exploit this sensitivity of qubits to spectroscopically detect individual TLSs, whose transition frequencies are tuned via applied physical strain and an electrical dc field. This experimental platform enables us to investigate coherence properties of individual TLSs in various quantum circuits and to draw conclusions about their density. Here we present the first strain and dc-field dependent spectroscopy of TLSs obtained with an Xmon sample. Especially, we propose a method to distinguish TLSs hosted in Josephson contacts from surface TLSs.