TT 5: Transport: Quantum Coherence and Quantum Information Systems - Experiment

Time: Monday 9:30–10:45 Location: HSZ 204

TT 5.1 Mon 9:30 HSZ 204

Coplanar microwave resonators for superconductor/cold atom hybrid devices — •Daniel Bothner, Martin Knufinke, Benedikt Ferdinand, Dominik Wiedmaier, Vasily Fedorov, Helge Hattermann, Patrizia Weiss, Lörinc Sárkány, József Fortágh, Dieter Koelle, and Reinhold Kleiner — Physikalisches Institut and Center for Collective Quantum Phenomena in LISA$^+$, Universität Tübingen, Germany

The realization of a hybrid quantum system consisting of a superconducting on-chip microwave resonator and an ultracold paramagnetic atomic ensemble poses severe challenges regarding the design and optimization of the superconducting chip. The resonators have to be integrated with atom trapping wires nearby, they are not allowed to add strong perturbations to the magnetic trapping fields and extra resonator losses due to Abrikosov vortices must be avoided or minimized. Moreover, the resonators should be magnetic field insensitively tunable and optical access to the chip surface has to be granted. In the presentation, we will elucidate these experimental boundary conditions and present strategies to comply with them on the way towards strong coupling between ultracold atomic ensembles and on-chip microwave resonators.

TT 5.2 Mon 9:45 HSZ 204

Tunable coupling between two superconducting microwave resonators — •Friedrich Wulschner[1], Jan Goetz[1], Borja Peropadre[3], Alexander Baust[1], Elisabeth Hoffmann[1,2], David Zueco[4], Frank Deppe[1,2], Edwin P. Menzel[1], Achim Marx[1], Juan Jose Garcia-Ripoll[3], and Rudolf Gross[1,2] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Physik-Department, TU München, Garching, Germany — [3]IFF-CSIC, Madrid, Spain — [4]CSIC-Universidad de Zaragoza and Fundacion ARAID, Spain

In the field of superconducting quantum circuits, experiments with a small number of qubits and/or resonators have been successfully performed to realize proof-of-principle quantum information architectures. For scaling up such systems, it is desirable to achieve controllable couplings between individual circuit elements. In our experiment, we demonstrate a tunable coupling between two transmission line resonators via an RF-SQUID. The RF-SQUID can be considered as a tunable mutual inductance which can change both sign and magnitude. We show spectroscopic data of the tunable coupler and explain the magnetic flux dependence of the coupling with a theoretical model.

We acknowledge support from the DFG via SFB 631, the German excellence initiative via NIM, and the EU via PROMISCE.

TT 5.3 Mon 10:00 HSZ 204

Squeezing with a flux-driven Josephson parametric amplifier — •L. Zhong[1], E. P. Menzel[1], R. Di Candia[3], P. Eder[1,2], M. Ihmig[4], A. Baust[1], M. Haeberlein[1,2], K. Inomata[5], T. Yamamoto[5,6], Y. Nakamura[5,7], E. Solano[3], F. Deppe[1,2], A. Marx[1], and R. Gross[1,2] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Physik-Department, TU München, Garching, Germany — [3]University of the Basque Country UPV/EHU and IKERBASQUE Foundation, Bilbao, Spain — [4]TU München, Germany — [5]RIKEN Center for Emergent Matter Science, Japan — [6]NEC Smart Energy Research Laboratories, Japan — [7]The University of Tokyo, Japan

Josephson parametric amplifiers (JPA) are promising devices for continuous-variable quantum communication. In phase-sensitive mode, JPAs can beat the standard quantum limit for the added noise of phase-insensitive amplifiers. This property is a prerequisite for the generation of squeezed states. Here, we reconstruct the Wigner function of squeezed vacuum and thermal states with the dual-path method [1,2]. In addition, we illuminate the physics of propagating squeezed coherent microwave fields.

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[1] L. Zhong *et al.*, arXiv:1307.7285 (2013)
[2] E. P. Menzel *et al.*, PRL **109** (2012) 250502

TT 5.4 Mon 10:15 HSZ 204

Interfacing rare earth spin ensembles with superconducting circuits — •Sebastian Probst[1], Andrej Tkalcec[1], Daniel Rieger[1], Hannes Rotzinger[1], Stefan Wünsch[2], Philipp Jung[1], Michael Siegel[2], Alexey V. Ustinov[1], and Pavel Bushev[3] — [1]Physikalisches Institut, KIT, 76128 Karlsruhe — [2]Institut für Mikro- und Nanoelektronische Systeme, KIT, 76189 Karlsruhe — [3]Institut für Experimentalphysik, Universität des Saarlandes, 66123 Saarbrücken

Interfacing photonic and solid-state qubits within a hybrid quantum architecture offers a promising route towards large scale distributed quantum computing. Ensembles of optically active rare earth spins embedded in a crystalline matrix are promising candidates for realizing such an interface. We report on single photon on-chip ESR spectroscopy of Er spin ensembles strongly coupled to superconducting and non superconducting microwave resonators [1,2]. The maximum coupling strength was measured to be 45 MHz at 200 ppm, and the minimum linewidth was 4 MHz at 50 ppm Er concentration, respectively. The strong anisotropy of Er:YSO prevents us from reaching the strong coupling regime at low field transitions. However, with crystals of higher symmetry such as YAP, strong coupling can be reached at relatively small magnetic fields of 30 mT at 5 GHz. In addition, we measured T_2 of the spins at millikelvins of about 40 μs. The experiments demonstrate the potential of rare earth ion doped crystals for their application in quantum information processing and communication. [1] Phys. Rev. B 84, 06051 (R) (2011), [2] Phys. Rev. Lett. 110, 157001 (2013)

TT 5.5 Mon 10:30 HSZ 204

Nuclear Spin Polarization in Bulk ZnSe:F — •Fabian Heisterkamp[1], Eugeny A. Zhukov[1], Vladimir L. Korenev[2], Alex Greilich[1], Alexander Pawlis[3], Dmitri R. Yakovlev[1,2], and Manfred Bayer[1] — [1]Experimentelle Physik 2, Technische Universität Dortmund, 44221 Dortmund, Germany — [2]Ioffe Physical-Technical Institute, Russian Academy of Sciences, 194021 St. Petersburg, Russia — [3]Department Physik, Universität Paderborn, 33098 Paderborn, Germany

Fluorine donor in ZnSe has been considered as a promising candidate for a quantum bit [1]. It is therefore crucial to study the influence of the environment on the spin coherence. In particular, we perform a study of interaction between electron and nuclei spins. Using the time-resolved optical pump-probe spectroscopy in the regime of resonant spin amplification we are able to resolve nuclear magnetic resonances (NMR) of ^{77}Zn and ^{67}Se isotopes with non-zero spin. The effective nuclei fields show a dispersive form of its strength around NMR as a function of magnetic field. Dependences of that signal are measured as a function of external parameters, like: pump power, polarization modulation frequency and temperature. Theoretical considerations support our findings.

[1] Sanaka et al., Phys. Rev. Lett. **103**, 053601 (2009).