TT 10 Symposium Solid State Meets Quantum Optics

Time: Monday 14:30–17:30 Room: HSZ 02

Invited Talk TT 10.1 Mon 14:30 HSZ 02

Circuit QED: Quantum Optics With Superconducting Electrical Circuits — •Steven Girvin — Sloane Physics Lab, Yale University, New Haven, CT 06520-8120 USA

Recent experimental breakthroughs have led to the construction of artificial superconducting ‘atoms’: electrical circuit elements whose state variables (voltages and currents) are intrinsically quantum mechanical. When placed inside a high Q resonator, these ‘atoms’ can strongly interact with single microwave photons. Tests of this new realization of strong-coupling cavity QED are now underway in the labs of Rob Schoelkopf and Michel Devoret at Yale. Recent experimental and theoretical results on quantum control, measurement and back action will be presented. Practical possibilities for generation of photon Fock states and squeezed vacuum states will be discussed. In addition to being a new test bed for quantum optics, this architecture has many promising features for quantum computation.

Invited Talk TT 10.2 Mon 15:00 HSZ 02

Cooper-Pair Molasses: Cooling a Nanomechanical Resonator with Quantum Noise — •Keith Schwab[1], Akshay Naik[1], Olivier Buu[1], Matthew LaHaye[1], Aashish Clerk[2], Andrew Armour[3], and Miles Blencowe[4] — [1]Laboratory for Physical Sciences and University of Maryland, College Park — [2]McGill University — [3]University of Nottingham — [4]Dartmouth College

We are performing ultra-low temperature experiments with a radio-frequency, nanomechanical resonator coupled to a superconducting single electron transistor, a system which has demonstrated the closest approach to the uncertainty principle for continuous position detection, and the closest approach to the quantum ground state of a mechanical system [1]. Recently, we have used the resonator to detect the asymmetric, quantum noise of the SET, which produces the back-action close to what is required by the uncertainty principle. In addition, have discovered an unexpected cooling mechanism, analogous to optical molasses, which is a result of resonant Josephson effects in the transistor. Using these techniques and devices, we are anticipating the observation of squeezed, superposition, and entangled states of a mechanical device. One future application for this technology could be in quantum information devices.
[1] LaHaye, Buu, Camarota, Schwab, "Approaching the Quantum Limit of a Nanomechanical Resonator," Science 304, 74 (2004).

Keynote Talk TT 10.3 Mon 15:30 HSZ 02

Fermionic atoms in a crystal structure of light — •Tilman Esslinger — ETH Zürich, Quantum Optics, HPF D4, Hönggerberg, CH-8093-Zürich

A general introduction to the physics of ultracold atoms in optical lattices will be given. These systems provide a new avenue for designing and studying many-body quantum systems. Exposed to the crystal structure of interfering laser waves the fermionic atoms behave much like electrons in a solid. However, the properties of this synthetic material can be changed at will. The collisional interaction between fermionic atoms in different spin states can be tuned using a Feshbach resonance and the dimensionality is controlled almost like a parameter. In the experiment we have been able to directly image the Fermi surface of the atoms in the optical lattice and to study the transition of the system from a conducting state to a band insulator. Using a Feshbach resonance we have dynamically induced a coupling between the lowest energy bands and formed molecules in the optical lattice. The unique versatility of atoms in optical lattices may allow the study of a whole catalogue of phenomena linked to solid-state physics or even to mimic the physics underlying high-temperature superconductivity.

— 15 min. break —

Keynote Talk TT 10.4 Mon 16:30 HSZ 02

Nonclassical States, Tomography, and Quantum Information in Circuit QED — •E. Solano[1,2], M. Mariantoni[3], M.J. Storcz[4], F.K. Wilhelm[4], W.D. Oliver[5], A. Emmert[3], A. Marx[3], R. Gross[3], and H. Christ[1] — [1]Max-Planck Institute for Quantum Optics, Hans-Kopfermann-Strasse 1, D-85748 Garching, Germany — [2]Sección Física, Departamento de Ciencias, Pontificia Universidad Católica del Perú, Apartado 1761, Lima, Peru — [3]Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meissner-Strasse 8, D-85748 Garching, Germany — [4]Department Physik, CeNS and ASC, LMU, Theresienstrasse 37, D-80333 München, Germany — [5]MIT Lincoln Laboratory, 244 Wood Street, Lexington, Massachussets 02420, USA

We show that flux-based qubits can be coupled to superconductive resonators by means of a quantum-optical Raman excitation scheme and utilized for the deterministic generation of propagating microwave single photons. We introduce also a microwave quantum homodyne technique that enables the measurement of single photons and other weak signals, and full state reconstruction via quantum tomography, realizing linear optics on a chip [1]. These generation and measurement protocols are building blocks for the generation of nonclassical states [2] and the advent of quantum information [3] in the field of circuit QED.
[1] M. Mariantoni *et al.*, cond-mat/0509737.
[2] M.J. Storcz, M. Mariantoni, A. Emmert, R. Gross, F.K. Wilhelm, H. Christ, and E. Solano, in preparation.
[3] H. Christ, M. Mariantoni, and E. Solano, in preparation.
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Keynote Talk TT 10.5 Mon 17:00 HSZ 02

Integrated Atom Optics on a Bose-Einstein-Chip — •Claus Zimmermann — Physikalisches Institut, Universität Tübingen

Bose-Einstein condensates trapped in miniaturized magnetic traps offer interesting perspectives for integrated matter wave optics on a micro chip. In recent experiments the basic properties of such Bose-Einstein chips have been investigated including effects caused by the interaction of the atoms with chip surface. Now, first matter wave interferences have been observed on a chip. This opens the door for the construction of on chip atom interferometers for sensitive detection of forces and accelerations. For the future, superconducting micro traps may allow for tailoring novel quantum systems with condensates coupled to Cooper pair wave functions.