[1] *Schneider U., Hackermuller L., Ronzheimer J.P., Will S., Braun S., Best T., Bloch I., Demler E., Mandt S., Rasch D., and Rosch A.*
Fermionic transport and out-of-equilibrium dynamics in a homogeneous hubbard model with ultracold atoms.
Nature Physics **advance online publication** (January 2012).
Transport properties are among the defining characteristics of many important phases in condensed-matter physics. In the presence of strong correlations they are difficult to predict, even for model systems such as the Hubbard model. In real materials, additional complications arise owing to impurities, lattice defects or multi-band effects. Ultracold atoms in contrast offer the possibility to study transport and out-of-equilibrium phenomena in a clean and well-controlled environment and can therefore act as a quantum simulator for condensed-matter systems. Here we studied the expansion of an initially confined fermionic quantum gas in the lowest band of a homogeneous optical lattice. For non-interacting atoms, we observe ballistic transport, but even small interactions render the expansion almost bimodal, with a dramatically reduced expansion velocity. The dynamics is independent of the sign of the interaction, revealing a novel, dynamic symmetry of the Hubbard model.

[2] *Rastelli G., Houzet M., Glazman L.I., and Pistolesi F.*
Interplay of magneto-elastic and polaronic effects in electronic transport through suspended carbon-nanotube quantum dots.
arXiv:1202.2344 (February 2012).
We investigate the electronic transport through a suspended carbon-nanotube quantum dot. In the presence of a magnetic field perpendicular to the nanotube and a nearby metallic gate, two forces act on the electrons: the Laplace and the electrostatic force. They both induce coupling between the electrons and the mechanical transverse oscillation modes. We find that the difference between the two mechanisms appears in the cotunneling current.

[3] *Yang C. and Han S.*
Generation of GHZ entangled states of photons in multiple cavities via a superconucting qubit or an atom through resonant interaction.
arXiv:1202.2084 (February 2012).
We propose a method to generate a GHZ entangled state of n photons in n microwave cavities (or resonators) via resonant interaction to a single superconducting qubit. By performing local operations on a qubit (e.g., a solid-state qubit, an atom, etc.) placed in each cavity, the created GHZ states of n photons can be transferred to qubits for storage. The proposed scheme greatly reduces effect of decoherence since only resonant qubit-cavity interaction and resonant qubit-pulse interaction are involved, and no measurement is required. In addition, we show that the method can be applied to create a GHZ state of photons in multiple cavities via an atom through resonant interaction with no measurement needed.

[4] *Williams J.R., Bestwick A.J., Gallagher P., Hong S.S., Cui Y., Bleich A.S., Analytis J.G., Fisher I.R., and Goldhaber-Gordon D.*
Signatures of majorana fermions in hybrid Superconductor-Topological insulator devices.
arXiv:1202.2323 (February 2012).
The ability to measure and manipulate complex particles in the solid state is a cornerstone of modern condensed-matter physics. Typical excitations of a sea of electrons, called quasiparticles, have properties similar to those of free electrons. However, in recent years exotic excitations with very different properties have been created in designer quantum materials, including Dirac fermions in graphene [1] and fractionally charged quasiparticles in fractional quantum Hall systems [2]. Here we report signatures of a new quasiparticle – the Majorana fermion – in Josephson junctions consisting of two superconducting leads coupled through a three-dimensional topological insulator [3]. We observe two striking departures from the common transport properties of Josephson junctions: a characteristic energy that scales inversely with the width of the junction, and a low characteristic magnetic field for suppressing supercurrent. To explain these effects, we propose a phenomenological model in which a one-dimensional wire of Majorana fermions is present along the width of the junction, similar to a theoretical prediction by Fu and Kane [4]. These results present an opening into the investigation of Majorana fermions in the solid state and their exotic properties, including non-Abelian statistics [5], a suggested basis for fault-tolerant quantum computation [6].

[5] *Anwar H., Campbell E.T., and Browne D.E.*
Qutrit magic state distillation.
arXiv:1202.2326 (February 2012).
Magic state distillation (MSD) is a purification protocol that plays a central role in fault tolerant quantum computation.

Repeated iteration of the steps of a MSD protocol, generates pure single non-stabilizer states, or magic states, from multiple copies of a mixed resource state using stabilizer operations only. Thus mixed resource states promote the stabilizer operations to full universality. Magic state distillation was introduced for qubit-based quantum computation, but little has been known concerning MSD in higher dimensional qudit-based computation. Here, we describe a general approach for studying MSD in higher dimensions. We use it to investigate the features of a qutrit MSD protocol based on the 5-qutrit stabilizer code. We show that this protocol distills non-stabilizer magic states, and identify two types of states, that are attractors of this iteration map. Finally, we show how these states may be converted, via stabilizer circuits alone, into a state suitable for state injected implementation of a non-Clifford phase gate, enabling non-Clifford unitary computation.

[6] *Altland A. and Haake F.*
Quantum chaos and effective thermalization.
Phys. Rev. Lett. **108**, 073601 (Feb 2012).
We demonstrate effective equilibration for unitary quantum dynamics under conditions of classical chaos. Focusing on the paradigmatic example of the Dicke model, we show how a constructive description of the thermalization process is facilitated by the Glauber Q or Husimi function, for which the evolution equation turns out to be of Fokker-Planck type. The equation describes a competition of classical drift and quantum diffusion in contractive and expansive directions. By this mechanism the system follows a "quantum smoothened" approach to equilibrium, which avoids the notorious singularities inherent to classical chaotic flows.

[7] *Nakano Y., Ishima T., Kobayashi N., Yamamoto T., Ichinose I., and Matsui T.*
Finite-temperature phase diagram of two-component bosons in a cubic optical lattice: Three-dimensional t-j model of hard-core bosons.
Phys. Rev. A **85**, 023617 (Feb 2012).
We study the three-dimensional bosonic t-J model, i.e., the t-J model of "bosonic electrons," at finite temperatures. This model describes the s=1/2 Heisenberg spin model with the anisotropic exchange coupling J=αJ_z and doped bosonic holes, which is an effective system of the Bose-Hubbard model with strong repulsions. The bosonic "electron" operator B_{rz} at the site r with a two-component (pseudo)spin σ(=1,2) is treated as a hard-core boson operator. By means of Monte Carlo simulations, we study its finite-temperature phase structure including the α dependence, the possible phenomena-like appearance of checkerboard long-range order, supercounterflow, superfluidity, phase separation, etc. The obtained results, which clarify the relation between various phases, may be taken as predictions about experiments of two-component cold bosonic atoms in a cubic optical lattice.

[8] *Barnett R., Powell S., Graß T., Lewenstein M., and Das Sarma S.*
Order by disorder in spin-orbit-coupled bose-einstein condensates.
Phys. Rev. A **85**, 023615 (Feb 2012).
Motivated by recent experiments, we investigate the system of isotropically interacting bosons with Rashba spin-orbit coupling. At the noninteracting level, there is a macroscopic ground-state degeneracy due to the many ways bosons can occupy the Rashba spectrum. Interactions treated at the mean-field level restrict the possible ground-state configurations, but there remains an accidental degeneracy not corresponding to any symmetry of the Hamiltonian, indicating the importance of fluctuations. By finding analytical expressions for the collective excitations in the long-wavelength limit and through numerical solution of the full Bogoliubov-de Gennes equations, we show that the system condenses into a single-momentum state of the Rashba spectrum via the mechanism of order by disorder. We show that in three dimensions the quantum depletion for this system is small, while the thermal depletion has an infrared logarithmic divergence, which is removed for finite-size systems. In two dimensions, on the other hand, thermal fluctuations destabilize the system.

[9] *Liu X.J., Jiang L., Pu H., and Hu H.*
Probing majorana fermions in spin-orbit-coupled atomic fermi gases.
Phys. Rev. A **85**, 021603 (Feb 2012).
We examine theoretically the visualization of Majorana fermions in a two-dimensional trapped ultracold atomic Fermi gas with spin-orbit coupling. By increasing an external Zeeman field, the trapped gas transits from a nontopological to a topological superfluid, via a mixed phase in which both types of superfluids coexist. We show that the zero-energy Majorana fermion, supported by the topological superfluid and localized at the vortex core, may be visible through (i) the core density and (ii) the local density of states, which are readily measurable in experiment. We present a realistic estimate on experimental parameters for ultracold ^{40}K atoms.