Macroscopic Quantum Mechanics in a Classical Spacetime
Huan Yang, Haixing Miao, Da-Shin Lee, Bassam Helou, Yanbei Chen
Phys. Rev. Lett. **110**, 170401 (2013)
We apply the many-particle Schrödinger-Newton equation, which describes the coevolution of a many-particle quantum wave function and a classical space-time geometry, to macroscopic mechanical objects. By averaging over motions of the objects' internal degrees of freedom, we obtain an effective Schrödinger-Newton equation for their centers of mass, which can be monitored and manipulated at quantum levels by state-of-the-art optomechanics experiments. For a single macroscopic object moving quantum mechanically within a harmonic potential well, its quantum uncertainty is found to evolve at a frequency different from its classical eigenfrequency—with a difference that depends on the internal structure of the object—and can be observable using current technology. For several objects, the Schrödinger-Newton equation predicts semiclassical motions just like Newtonian physics, yet quantum uncertainty cannot be transferred from one object to another.

Spin dynamics in a spin-orbit coupled Fermi gas
Stefan S. Natu, S. Das Sarma
arXiv:1305.2443
We study the dynamics of a non-degenerate, harmonically trapped Fermi gas following a sudden ramp of the spin-orbit coupling strength. In the non-interacting limit, we solve the Boltzmann equation in the presence of spin orbit coupling analytically, and derive expressions for the dynamics of an arbitrary initial spin state. In particular we show that for a fully spin polarized initial state, the total magnetization exhibits collapse and revival dynamics in time with a period set by the trapping potential. In real space, this corresponds to oscillations between a fully polarized state and a spin helix. We numerically study the effect of interactions on the dynamics using a collisionless Boltzmann equation.

Spontaneous synchronization and quantum correlation dynamics of open spin systems
G. L. Giorgi, F. Plastina, G. Francica, R. Zambrini
arXiv:1305.1816
We discuss the emergence of spontaneous synchronization for an open spin-pair system interacting only via a common environment. Under suitable conditions, and even in the presence of detuning between the natural precession frequencies of the two spins, they are shown to reach a long-lasting transient behavior where they oscillate in phase. We explore the connection between the emergence of such a behavior and the establishment of robust quantum correlations between the two spins, analyzing differences between dissipative and dephasing effects.

Collective strong coupling in multimode cavity QED
Arne Wickenbrock, Michal Hemmerling, Gordon R.M. Robb, Clive Emary, Ferruccio Renzoni
arXiv:1305.2579
We study an atom-cavity system in which the cavity has several degenerate transverse modes. Mode-resolved cavity transmission spectroscopy reveals well-resolved atom-cavity resonances for several cavity modes, a signature of collective strong coupling for the different modes. Furthermore, the experiment shows that the cavity modes are coupled via the atomic ensemble contained in the cavity. The experimental observations are supported by a detailed theoretical analysis. The work paves the way to the use of interacting degenerate modes in cavity-based quantum information processing, where qubits corresponding to different cavity modes interact via an atom shared by the two modes. Our results are also relevant to the experimental realization of quantum spin glasses with ultracold atoms.

Quantum teleportation of spin coherent states
Alexey Pyrkov, Tim Byrnes
arXiv:1305.2479
We introduce a quantum teleportation scheme that can transfer a macroscopic spin coherent state between two locations. In the scheme a large number of copies of a qubit, such as realized in a coherent two-component Bose-Einstein condensate, is teleported onto a distant macroscopic spin coherent state using only elementary operations and measurements. We analyze the error of the protocol with the number of particles N in the spin coherent state under decoherence and find that it scales favorably with N.

Interaction and disorder effects in 3D topological insulator thin films
E. J. König, P. M. Ostrovsky, I. V. Protopopov, I. V. Gornyi, I. S. Burmistrov, A. D. Mirlin
arXiv:1305.2820
A theory of combined interference and interaction effects on the diffusive transport properties of 3D topological insulator surface states is developed. We focus on a slab geometry (characteristic for most experiments) and show that interactions between the top and bottom surfaces are important at not too high temperatures. We treat the general case of different surfaces (different carrier densities, uncorrelated disorder, arbitrary dielectric environment, etc.). In order to access the low-energy behavior of the system we renormalize the interacting diffusive sigma model in the one loop approximation. It is shown that intersurface interaction is relevant in the renormalization group (RG) sense and the case of decoupled surfaces is therefore

unstable. An analysis of the emerging RG flow yields a rather rich behavior. We discuss realistic experimental scenarios and predict a characteristic non-monotonic temperature dependence of the conductivity. In the infrared (low-temperature) limit, the systems flows into a metallic fixed point. At this point, even initially different surfaces have the same transport properties. Investigating topological effects, we present a local expression of the $\mathbb{Z}_2$ theta term in the sigma model by first deriving the Wess-Zumino-Witten theory for class DIII by means of non-abelian bosonization and then breaking the symmetry down to AII. This allows us to study a response of the system to an external electromagnetic field. Further, we discuss the difference between the system of Dirac fermions on the top and bottom surfaces of a topological insulator slab and its non-topological counterpart in a double-well structure with strong spin-orbit interaction.

Nonlinear Quantum Optomechanics via Individual Intrinsic Two-Level Defects
Tomás Ramos, Vivishek Sudhir, Kai Stannigel, Peter Zoller, and Tobias J. Kippenberg
Phys. Rev. Lett. 110, 193602 (2013)
We propose to use the intrinsic two-level system (TLS) defect states found naturally in integrated optomechanical devices for exploring cavity QED-like phenomena with localized phonons. The Jaynes-Cummings-type interaction between TLS and mechanics can reach the strong coupling regime for existing nano-optomechanical systems, observable via clear signatures in the optomechanical output spectrum. These signatures persist even at finite temperature, and we derive an explicit expression for the temperature at which they vanish. Further, the ability to drive the defect with a microwave field allows for realization of phonon blockade, and the available controls are sufficient to deterministically prepare non-classical states of the mechanical resonator.

Composite Fermions with Tunable Fermi Contour Anisotropy
D. Kamburov, Yang Liu, M. Shayegan, L. N. Pfeiffer, K. W. West, and K. W. Baldwin
Phys. Rev. Lett. 110, 206801 (2013)
The composite fermion formalism elegantly describes some of the most fascinating behaviors of interacting two-dimensional carriers at low temperatures and in strong perpendicular magnetic fields. In this framework, carriers minimize their energy by attaching two flux quanta and forming new quasiparticles, the so-called composite fermions. Thanks to the flux attachment, when a Landau level is half-filled, the composite fermions feel a vanishing effective magnetic field and possess a Fermi surface with a well-defined Fermi contour. Our measurements in a high-quality two-dimensional hole system confined to a GaAs quantum well demonstrate that a parallel magnetic field can significantly distort the hole-flux composite fermion Fermi contour.

Expansion Dynamics of Interacting Bosons in Homogeneous Lattices in One and Two Dimensions
J. P. Ronzheimer, M. Schreiber, S. Braun, S. S. Hodgman, S. Langer, I. P. McCulloch, F. Heidrich-Meisner, I. Bloch, and U. Schneider, Phys. Rev. Lett. 110, 205301 (2013)
We experimentally and numerically investigate the expansion of initially localized ultracold bosons in homogeneous one- and two-dimensional optical lattices. We find that both dimensionality and interaction strength crucially influence these nonequilibrium dynamics. While the atoms expand ballistically in all integrable limits, deviations from these limits dramatically suppress the expansion and lead to the appearance of almost bimodal cloud shapes, indicating diffusive dynamics in the center surrounded by ballistic wings. For strongly interacting bosons, we observe a dimensional crossover of the dynamics from ballistic in the one-dimensional hard-core case to diffusive in two dimensions, as well as a similar crossover when higher occupancies are introduced into the system.

Adiabatic quantum pumping of chiral Majorana fermions
M. Alos-Palop, Rakesh P. Tiwari, M. Blaauboer, arXiv:1305.1512

Integer and Fractional Quantum Hall Effect in a Strip of Stripes
Jelena Klinovaja, Daniel Loss, arXiv:1305.1569

Reflection Positivity for Majorana Fermions
Arthur Jaffe, Fabio L. Pedrocchi, arXiv:1305.1792

Point contacts and localization in generic helical liquids
Christoph P. Orth, Grégory Strübi, Thomas L. Schmidt, arXiv:1305.1875

Long-Range Interaction of Singlet-Triplet Qubits via Ferromagnets
Luka Trifunovic, Fabio L. Pedrocchi, Daniel Loss, arXiv:1305.2451

Strategy for implementing stabilizer-based codes on solid-state qubits
Tetsufumi Tanamoto, Vladimir M. Stojanović, Christoph Bruder, and Daniel Becker, Phys. Rev. A 87, 052305 (2013)