[1] *Pino M., Prior J., Somoza A.M., Jaksch D., and Clark S.R.*
Re-entrance and entanglement in the one-dimensional bose-hubbard model.
arXiv **1206.0222**.
Re-entrance is a novel feature where the phase boundaries of a system exhibit a succession of transitions between two phases A and B, like A-B-A-B, when just one parameter is varied monotonically. This type of re-entrance is displayed by the 1D Bose Hubbard model between its Mott insulator (MI) and superfluid phase as the hopping amplitude is increased from zero. Here we analyse this counter-intuitive phenomenon directly in the thermodynamic limit by utilizing the infinite time-evolving block decimation algorithm to variationally minimize an infinite matrix product state (MPS) parameterized by a matrix size χ. Exploiting the direct restriction on the half-chain entanglement imposed by fixing chi, we determined that re-entrance in the MI lobes only emerges in this approximate when $\chi \geq 8$. This entanglement threshold is found to be coincident with the ability an infinite MPS to be simultaneously particle-number symmetric and capture the kinetic energy carried by particle-hole excitations above the MI. Focussing on the tip of the MI lobe we then applied, for the first time, a general finite-entanglement scaling analysis of the infinite order Kosterlitz-Thouless critical point located there. By analysing χ's up to a very moderate $\chi = 70$ we obtained an estimate of the KT transition as $t_K T = 0.30$ +/- 0.01, demonstrating the how a finite-entanglement approach can provide not only qualitative insight but also quantitatively accurate predictions.

[2] *Lang N. and Büchler H.P.*
Minimal instances for toric code ground states.
arXiv **1206.6994**.
A decade ago Kitaev's toric code model established the new paradigm of topological quantum computation. Due to remarkable theoretical and experimental progress, the quantum simulation of such complex many-body systems is now within the realms of possibility. Here we consider the question, to which extent the ground states of small toric code systems differ from LU-equivalent graph states. We argue that simplistic (though experimentally attractive) setups obliterate the differences between the toric code and equivalent graph states; hence we search for the smallest setups on the square- and triangular lattice, such that the quasi-locality of the toric code hamiltonian becomes a distinctive feature. To this end, a purely geometric procedure to transform a given toric code setup into an LC-equivalent graph state is derived. In combination with an algorithmic computation of LC-equivalent graph states, we find the smallest non-trivial setup on the square lattice to contain 5 plaquettes and 16 qubits; on the triangular lattice the number of plaquettes and qubits is reduced to 4 and 9, respectively.

[3] *Michalakis S.*
Stability of the area law for the entropy of entanglement.
arXiv **1206.6900**.
Recent results on the stability of the spectral gap under general perturbations for frustration-free Hamiltonians, have motivated the following question: Does the entanglement entropy of quantum states that are connected to states satisfying an area law along gapped Hamiltonian paths, also satisfy an area law? We answer this question in the affirmative, combining recent advances in quasi-adiabatic evolution and Lieb-Robinson bounds with ideas from the proof of the 1D area law.

[4] *Ngo V.A. and Haas S.*
Demonstration of jarzynski's equality in open quantum systems using a step-wise pulling protocol.
arXiv **1206.6909**.
We present a generalization of Jarzynski's Equality, applicable to quantum systems, relating discretized mechanical work and free-energy changes. The theory is based on a step-wise pulling protocol. We find that work distribution functions can be constructed from fluctuations of a reaction coordinate along a reaction pathway in the step-wise pulling protocol. We also propose two sets of equations to determine the two possible optimal pathways that provide the most significant contributions to free-energy changes. We find that the transitions along these most optimal pathways, satisfying both sets of equations, follow the principle of detailed balance. We then test the theory by explicitly computing the free-energy changes for a one-dimensional quantum harmonic oscillator. This approach suggests a feasible way of measuring the fluctuations to experimentally test Jarzynski's Equality in many-body systems, such as Bose-Einstein condensates.

[5] *Hwang M.J. and Choi M.S.*
Large-scale schrödinger-cat states and majorana bound states in coupled circuit-qed systems.
arXiv **1207.0088**.

We have studied the low-lying excitations of a chain of coupled circuit-QED systems, and report several intriguing properties of its two nearly degenerate ground states. The ground states are Schrödinger cat states at a truly large scale, involving maximal entanglement between the resonator and the qubit, and are mathematically equivalent to Majorana bound states. With a suitable design of physical qubits, they are protected against local fluctuations and constitute a non-local qubit. Further, they can be probed and manipulated coherently by attaching an empty resonator to one end of the circuit-QED chain.

[6] *Ghaemi P., Cayssol J., Sheng D.N., and Vishwanath A.*
Fractional topological phases and broken time-reversal symmetry in strained graphene.
Phys. Rev. Lett. **108**, 266801 (Jun 2012).
We show that strained or deformed honeycomb lattices are promising platforms to realize fractional topological quantum states in the absence of any magnetic field. The strain-induced pseudomagnetic fields are oppositely oriented in the two valleys and can be as large as 60-300 T as reported in recent experiments. For strained graphene at neutrality, a spin- or a valley-polarized state is predicted depending on the value of the on-site Coulomb interaction. At fractional filling, the unscreened Coulomb interaction leads to a valley-polarized fractional quantum Hall liquid which spontaneously breaks time-reversal symmetry. Motivated by artificial graphene systems, we consider tuning the short-range part of interactions and demonstrate that exotic valley symmetric states, including a valley fractional topological insulator and a spin triplet superconductor, can be stabilized by such interaction engineering.

[7] *Ki D.K. and Morpurgo A.F.*
Crossover from coulomb blockade to quantum hall effect in suspended graphene nanoribbons.
Phys. Rev. Lett. **108**, 266601 (Jun 2012).
Suspended graphene nanoribbons formed during current annealing of suspended graphene flakes have been investigated experimentally. Transport measurements show the opening of a transport gap around charge neutrality due to the formation of Coulomb islands, coexisting with quantum Hall conductance plateaus appearing at moderate values of the magnetic field B. Upon increasing B, the transport gap is rapidly suppressed, and is taken over by a much larger energy gap due to electronic correlations. Our observations show that suspended nanoribbons allow the investigation of phenomena that could not so far be accessed in ribbons on SiO_2 substrates.

[8] *Lemonik Y., Aleiner I., and Fal'ko V.I.*
Competing nematic, antiferromagnetic, and spin-flux orders in the ground state of bilayer graphene.
Phys. Rev. B **85**, 245451 (Jun 2012).
We analyze the phase diagram of bilayer graphene (BLG) at zero temperature and zero doping. Assuming that at high energies the electronic system of BLG can be described within a weak-coupling theory (consistent with the experimental evidence), we systematically study the evolution of the couplings with going from high to low energies. The divergences of the couplings at some energies indicate the tendency towards certain symmetry breakings. Carrying out this program, we found that the phase diagram is determined by microscopic couplings defined on the short distances (initial conditions). We explored all plausible space of these initial conditions and found that the three states have the largest phase volume of the initial couplings: nematic, antiferromagnetic, and spin flux (a.k.a. quantum spin Hall). In addition, ferroelectric and two superconducting phases appear only near the very limits of the applicability of the weak-coupling approach. The paper also contains the derivation and analysis of the renormalization group equations and the group theory classification of all the possible phases which might arise from the symmetry breakings of the lattice, spin rotation, and gauge symmetries of graphene.

[9] *Stojanovic V.M., Shi T., Bruder C., and Cirac J.I.*
Quantum simulation of small-polaron formation with trapped ions.
arXiv **1206.7010**.
We propose a method for simulating polaron physics using a one-dimensional system of trapped ions acted upon by off-resonant standing waves. This system, envisioned as an array of ion microtraps, in the single-excitation case provides a realization of the anti-adiabatic regime of the Holstein model. We show that the strong excitation-phonon coupling regime, characterized by the formation of small polarons, can be reached using realistic values of the relevant system parameters. Finally, we propose measurements of the quasiparticle residue and the average number of phonons in the ground state, experimental probes validating the polaronic character of the phonon-dressed excitation.