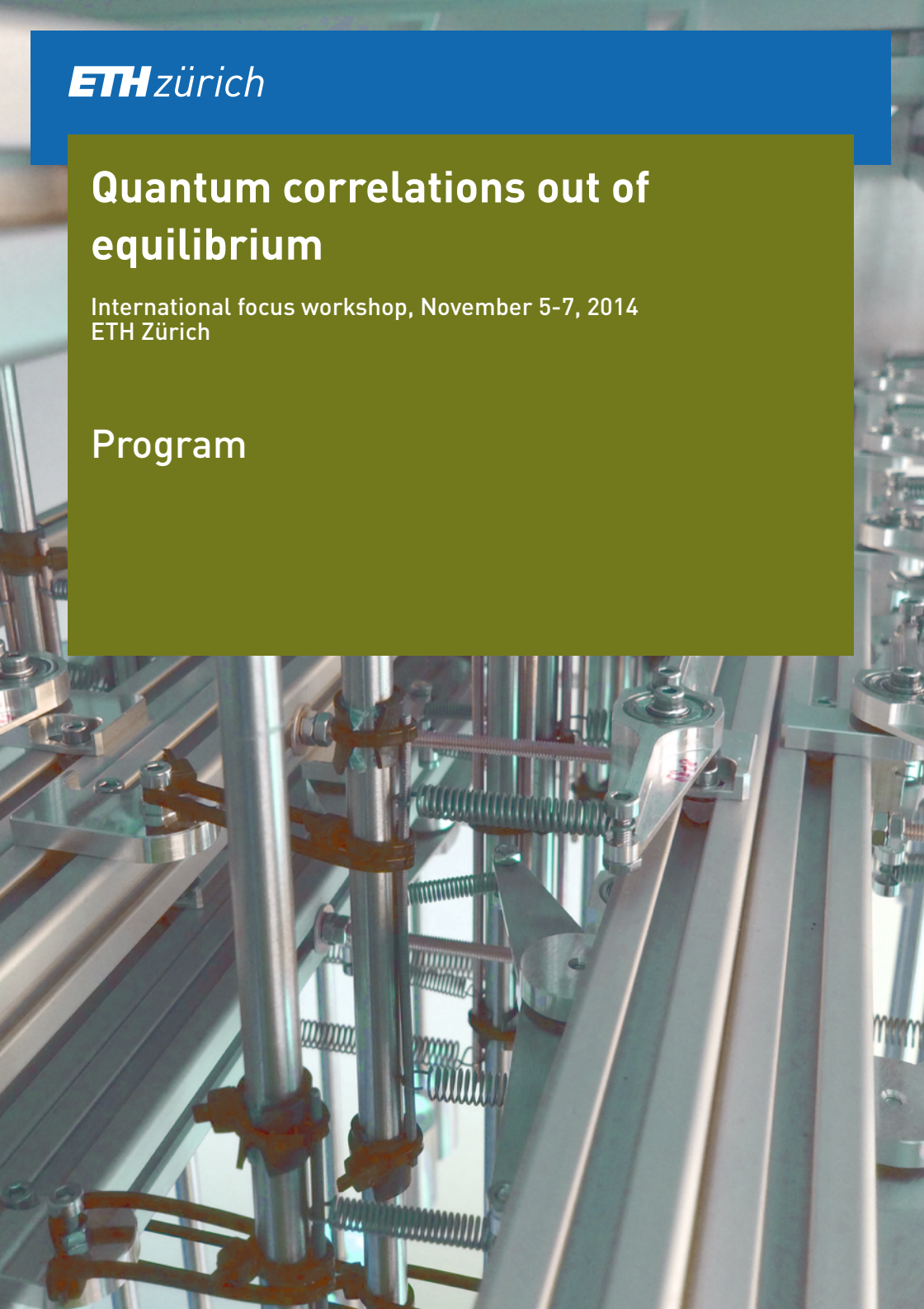
ETH zürich

Quantum correlations out of equilibrium

International focus workshop, November 5-7, 2014
ETH Zürich

Program



Program

All talk will be held in HPZ E35
All talks are optimally 30'+15'
Flash talks are 4' each followed by a full afternoon of discussion

Wednesday	13:30	Opening Remarks
	13:35	Mark Rudner
	14:10	Ari Turner
	14:55	Discussions
	16:15	Ehud Altman (Colloquium, HPV G4)
	17:00	Apero and Beer after the Colloquium
	19:00	Conference dinner

Thursday	09:00	Erez Berg
	09:45	Björn Trauzettel
	10:30	Coffee
	11:00	Assa Auerbach
	11:45	Netanel Lindner
	12:30	Lunch

Program

Thursday	14:00	Flash Talks
	15:00	Discussions
	16:00	Coffee and cookies (HPV)
	16:30	Discussions
	18:30	Individual dinner
Friday	09:00	Iacopo Carusotto
	09:45	Mikael Rechtsman
	10:30	Coffee
	11:00	Oded Zilberberg
	11:45	Mohammad Hafezi
	12:30	Lunch
	14:00	Ehud Altman
	14:45	Lukas Sieberer
	15:30	Yoav Lahini
	16:15	Coffe and cookies
	16:45	Frank Pollmann
	17:30	Closing remarks

Abstracts

Mark Rudner

Interactions and dissipation in Floquet-band systems

Recently many authors have explored possibilities for dynamically altering band structures through the application of time-periodic driving fields. Particular excitement surrounds the possibility of controlling the topology of the resulting "Floquet bands," which are described by an even richer topological classification than that of conventional topological insulators. While many schemes have been proposed for realizing interesting Floquet band structures, crucia questions remain about the filling of the corresponding time-dependent single particle states, as well as the roles of interactions and dissipation. In this work we study the roles of interactions, heating, and dissipation in the population kinetics of one dimensional many-particle Floquet systems. While a naive picture might lead one to expect rapid heating of any strongly driven interacting system, we find wide parameter regimes in which non-trivial Floquet state distributions are obtained at intermediate and long times. Prospects for obtaining and probing the physics of many-body Floquet systems will be discussed.

Ari Turner

Spin Fluctuations and Entanglement

I will compare the effects of quantum and thermal fluctuations in a spin chain by calculating the probability distribution for spin fluctuations in a segment.

The calculation will use the concept of an "entanglement Hamiltonian." The entanglement Hamiltonian can be used to identify topological phases, but I will show that it is helpful for long-wavelength correlations as well as topological ones.
The entanglement Hamiltonian is an imaginary system that describes the correlations of the ground state. It cannot be measured directly, but it is related to the statistics of the fluctuations, so measuring the spin fluctuations of the atoms on the sites of an optical lattice is an indirect way of measuring the entanglement Hamiltonian.

Erez Berg

Coherent Transmutation of Electrons into Fractionalized Anyons

Electrons have three quantized properties – charge, spin, and Fermi statistics – that are directly responsible for a vast array of phenomena. Here we show how these properties can be coherently and dynamically stripped from the electron as it enters certain exotic states of matter

known as quantum spin liquids (QSL). In a QSL, electron spins collectively form a highly entangled quantum state that gives rise to emergent gauge forces and fractionalization of spin, charge, and statistics. We show that certain QSLs host distinct, topologically robust boundary types, some of which allow the electron to coherently enter the QSL as a fractionalized quasiparticle, leaving its spin, charge, or statistics "at the door." We use these ideas to propose a number of universal, "smoking-gun" experimental signatures that would establish fractionalization in QSLs.

Björn Trauzettel

Gapless topological phases

Topologically protected surface states and a gapped bulk spectrum are the most prominent fingerprints of topological phases of matter. In this talk, we discuss two schemes for generating Hamiltonians that represent an unusual class of topological phases with coexisting gapless bulk spectrum and well-localized edge states. We demonstrate that, in the clean limit, the edge states of the proposed models possess the same character. Furthermore, we show that the gapless phases may be classi fied according to their topological classi cation in the presence an arti cially induced in finitesimal bulk gap, which furthermore determines the localization properties of the model. Additionally, we suggest a concrete physical realization to one of the models based on a magnetically doped three dimensional topological insulator in proximity to a superconductor.

Assa Auerbach

CORE results for the Kagome Antiferromagnet: Spin liquid with p_6 chirality

The kagome Heisenberg antiferromagnet is mapped onto an effective Hamiltonian on the star superlattice by contractor renormalization. A comparison of ground-stat energies on large lattices to density matrix renormalization group justifies truncation of effective interactions at range 3 (36 sites). Within our accuracy, magnetic and translational symmetries are not broken (i.e., a spin liquid ground state). However, we discover doublet spectral degeneracies which signal the onset of p6 chirality symmetry breaking. This is understood by a simple mean field analysis. Experimentally, the p6 chiral order parameter should split the optical phonon degeneracy near the zone center.

Netanel Lindner

The Ising bagel: Non-Abelian statistics enriched by defects and their zero modes

Non-Abelian topological phases of matter can be utilized to encode and manipulate quantum information in a non-local manner, such that it is protected from imperfections in the implemented protocols and from interactions with the environment. However, the condition that the non-Abelian statistics of the anyons supports a computationally universal set

of gates sets a very stringent requirement which is not met by many topological phases. We consider the possibility to enrich the possibletopological operations supported by a non-Abelian topological phase by introducing defects into the system. We show that such defects bind zero modes which form a unique algebra that goes beyond the parafermionic algebra describing defects in Abelian phases. Furthermore, we show that by coupling zero modes, one can obtain a set of topological operations that implementsa universal set of gates. We also discuss lattice models of interacting defects and their implications to edge phases of non-Abelian topological phases.

Iacopo Carusotto

Quantum fluids of light: towards strongly correlated states

After a brief review of the general idea of a Quantum Fluids of Light and of a few pioneering experiments, I will explore the perspectives of using these systems for the study of strongly correlated many-body systems in novel regimes. A particular attention will be paid to the novel physics and the new possibilities that are opened by the intrinsically non-equilibrium, driven-dissipative nature of optical systems.

Mikael Rechtsman

Aspects of (Hermitian and non-Hermitian) photonic topological protection

I will discuss our experimental results demonstrating the topological protection of light. I will show that light launched into a honeycomb array of helical waveguides undergoes diffraction analogously to the motion of driven electrons in graphene. The time-dependent drive results in non-zero Chern numbers, topological edge states and immunity to scattering. I will also present recent results demonstrating a topological transition in a non-Hermitian photonic system (joint work with Mark Rudner's group). In the non-Hermitian case, it has been shown that the mean displacement of the wave-function is quantized - we measure topological numbers experimentally using this quantity.

Oded Zilberberg

Topological states in photonic systems

Recent technological advances have allowed for the generation of effective-gauge fields for photons in confined geometries. In such setups, photons mimic the behavior of non-interacting electrons on a lattice in the presence of such gauge potentials. For the electrons, there exists a topological quantized bulk response with a corresponding edge phenomena. However, due to the bosonic, driven and dissipative nature of the photonic systems, the bulk response is no longer quantized. Nonetheless, the boundary phenomena prevails. Additionally, in some circumstances the bulk index can still be read off from a small photonic system.

Mohammad Hafezi

Photons in gauge fields: from telecom to microwave domain

I report on the observation of chiral edge states of photons using silicon photonics. These states are topologically robust, in direct analogy to electronic systems. I show how a photonic system with localized transport in the bulk has robust transport along its edge. By developing statistics over different devices, one can confirm the suppression of localization in edge states. Furthermore, I discuss how similar physics can be observed in the microwave domain using circuit-QED architecture. The addition of nonlinearity to such photonic systems with synthetic gauge fields could lead to the generation of quantum many-body states similar to that of the fractional quantum Hall effect in electronic systems. I describe various schemes to prepare and detect such states.

Ehud Altman

TBA

Lukas Sieberer

Two-dimensional superfluidity of exciton-polaritons requires strong anisotropy

Fluids of exciton-polaritons, excitations of two dimensional quantum wells in optical cavities, show collective phenomena akin to Bose condensation. However, a fundamental difference from standard condensates stems from the finite lifetime of these excitations, which necessitate continuous driving to maintain a steady state. A basic question is whether a two dimensional condensate with long range algebraic correlations can exist under these non-equilibrium conditions. Here we show that such driven two-dimensional Bose systems cannot exhibit algebraic superfluid order except in low-symmetry, strongly anisotropic systems. Our result implies, in particular, that recent apparent evidence for Bose condensation of exciton-polaritons must be an intermediate scale crossover phenomenon, while the true long distance correlations fall off exponentially. We obtain these results through a mapping of the long-wavelength condensate dynamics onto the anisotropic Kardar-Parisi-Zhang equation.

Yoav Lahini

Strongly correlated quantum walks

The talk will describe the theoretical and experimental study of strongly correlates quantum walks in optical lattices. I will also present a view of future directions, including a study of the effect of disorder and the implementation of quantum-walk based information processing.

Frank Pollmann

Entanglement and dynamics in many-body localized systems

Many-body localized phases occur in isolated quantum systems when Anderson localization persists in the presence of finite interactions. It turns out that the entanglement is a very useful quantity to study these phases. First, we focus on the physics in the presence of strong disorder. For this we study the time evolution of simple (unentangled) initial states for a system of interacting spinless fermions in a one dimensional system. It is found that the interactions induce a dramatic change in the propagation of entanglement. Second, we use the entanglement of excited eigenstates to pinpoint a phase transition from a localized to an extended phase in a random Ising chain with short ranged interactions.

Useful information

Transportation

Except for the ride from the airport, all public transport connections are within zone 110. A day pass is equivalent to two single rides, hence it always pays to get the day pass.

Airport to hotel

Take tram Nr. 10 to "Milchbuck", the hotel "Coronado" is across the street (Schaffhauserstrasse 137).

Main station (HB) to hotel

Take tram Nr. 14 to "Milchbuck", the hotel is across the street.

Hotel to ETG Hönggerberg

Take Bus Nr. 69 to the final stop.

Internet

There is an eduroam network for those who have access. All others should use the network "public" with the username "quantum11" and password "equil1114".

If you get lost

Call Sebi:	+41 (0)78 673 01 90
or Oded:	+41 (0)76 573 22 08