Titles and abstracts of talks

Monday 16

Dmitry Abanin (Perimeter Institute)

Ergodicity, entanglement, and many-body localization

We are used to describing systems of many particles by statistical mechanics. However, the basic postulate of statistical mechanics – ergodicity -- breaks down in so-called many-body localized systems, where disorder prevents particle transport and thermalization. In this talk, I will present a theory of the many-body localized (MBL) phase, based on new insights from quantum entanglement. I will argue that, in contrast to ergodic systems, MBL eigenstates are not highly entangled. I will use this fact to show that MBL phase is characterized by an infinite number of emergent local conservation laws, in terms of which the Hamiltonian acquires a universal form.

Turning to the experimental implications, I will describe the response of MBL systems to quenches: surprisingly, entanglement shows logarithmic in time growth, reminiscent of glasses, while local observables exhibit power-law approach to "equilibrium" values. I will support the presented theory with results of numerical experiments. I will close by discussing experimental implications and other directions in exploring ergodicity and its breaking in quantum many-body systems, including periodically driven systems and MBL without quenched disorder.

Norbert Schuch

TBA

Tuesday 17

Andreas Lauchli

Entanglement Spectroscopy of Quantum Matter

The entanglement spectrum, i.e. the logarithm of the eigenvalues of reduced density matrices of quantum many body wave functions, has been the focus of a rapidly expanding research endeavor recently. Initially introduced by Li & Haldane in the context of the fractional quantum Hall effect, its usefulness has been shown to extend to many more fields, such as topological insulators, fractional Chern insulators, spin liquids, continuous symmetry breaking states, etc.

After a general introduction to the field we review some of our own contributions to the field, in particular the perturbative structure of the entanglement spectrum in gapped phases, the entanglement spectrum across the Mott-insulator transition in the Bose-Hubbard model, and the relation of the entanglement spectrum of (1+1) dimensional quantum critical systems to the operator content of their underlying CFT.

Nathan Goldman

Gauge fields and topological phases with cold atoms: Baby, you can drive my cloud!

Topological states of matter constitute one of the hottest disciplines in quantum physics, demonstrating a remarkable fusion between elegant mathematical theories and promising technological applications. Topology, which guarantees the robustness of unique properties, can be intrinsic to a material. Alternatively, it can be induced externally by subjecting the system to well-designed electromagnetic fields or mechanical deformations. In this talk, I will present a general framework that thoughtfully describes driven quantum systems. It enables one to identify versatile and practical driving schemes generating topological properties. A special emphasis will be set on the possibility to generate spin-orbit couplings in driven cold-atom systems.

Wednesday 18

Kareljan Schoutens

Supersymmetric quantum wires

We explore supersymmetric lattice models for charges on a 1-D chain, subject to an exclusion rule that allows up to k particles on neighboring sites. The order-k clustering property turns out to be similar to the clustering property of electrons in a Read-Rezayi fractional quantum Hall state with filling k/(k+2). In particular, the two systems are both linked to the k-th minimal model of N=2 superconformal field theory (SCFT).

Thursday 19

Michael Levin

TBA

Joel Moore

TBA

Immanuel Bloch

TBA

Eugene Demler

TBA

Frank Verstraete

TBA

Friday 20

Lukasz Cincio

Chiral spin liquid and emergent anyons in a Kagome lattice Mott insulator

Topological phases in frustrated quantum spin systems have fascinated researchers for decades. One of the earliest proposals for such a phase was the chiral spin liquid put forward by Kalmeyer and Laughlin in 1987 as the bosonic analogue of the fractional quantum Hall effect. Elusive for many years, recent times have finally seen a number of models that realize this phase. However, these models are somewhat artificial and unlikely to be found in realistic materials. Here, we take an important step towards the goal of finding a chiral spin liquid in nature by examining a physically motivated model for a Mott insulator on the Kagome lattice with broken time-reversal symmetry. We present an unambiguous numerical identification and characterization of the universal topological properties of the phase, including edge physics and anyonic bulk excitations, by using powerful numerical probes, including the entanglement spectrum and modular transformations.

Anushya Chandran

TBA

Monday 23

Ignacio Cirac

Symmetries and boundary theories for chiral Projected Entangled Pair State

We investigate the topological character of lattice chiral Gaussian fermionic states in two dimension possessing the simplest descriptions in terms of projected entangled-pair states (PEPS). As for (non-chiral) topological PEPS, it can be traced down to the existence of a symmetry in the virtual modes that are used to build the state. Based on that symmetry, we construct string-like operators acting on the virtual modes that can be continuously deformed without changing the state. On the torus, the symmetry implies that the ground state space of the local parent Hamiltonian is two-fold degenerate. By adding a string wrapping around the torus one can change one of the ground states into the other. We use the special properties of PEPS to build the boundary theory and show how the symmetry results in the appearance of chiral modes, and a universal correction to the area law for the zero R\'enyi entropy. We also provide a new example of a chiral state with Chern number $C=2$.

Manuel Endres

Probing quantum many-body systems at the single-particle level

In recent years, tremendous experimental progress has been made in probing strongly correlated many-body systems at the level of individual particles. For ultracold quantum gases, this was achieved using single-site- and single-atom-resolved imaging in optical lattices. With this technique, ‘snapshots’ of a fluctuating many-body system are obtained, where individual excitations are directly visible and, by shining light through the imaging system, are also directly addressable.

I will review these developments and present a few chosen experiments in more detail: The single-site-resolved detection of correlation functions [1], and the detection of an amplitude ‘Higgs’ mode [2], and the observation of the quantum dynamics of a mobile spin impurity [3]. I will conclude with analyzing the current limitations and possible future developments, e.g., the detection of entanglement in quantum many-body systems. Concerning the latter topic, I will present preliminary data indicating the experimental quantification of entanglement generated during single-spin impurity dynamics.

[1] M. Endres et al., Science 334, 200 (2011)
[2] M. Endres et al., Nature 487, 454-458 (2012)
[3] T. Fukuhara et al., Nature Phys. 9, 235 (2013)

Tuesday 24

Duncan Haldane

TBA

Matthew Fisher

TBA

Ehud Altman

TBA

Xiao-Gang Wen

TBA

Paul Fendley

Topological order from parafermions

Much effort has been devoted to the study of systems with topological order, motivated by practical issues as well as more field-theoretical and mathematical concerns. A sign of topological order in a gapped one-dimensional quantum chain is the existence of edge zero modes. These occur in the Z_2-invariant Ising/Majorana chain, where they can be understood using free-fermion techniques. Here I show they also occur in strongly interacting spin chains with Z_n symmetry, and are naturally expressed in terms of parafermions. Strikingly, these edge zero modes do not occur in the usual ferromagnetic and antiferromagnetic cases, but rather only when the interactions are chiral, so that spatial-parity and time-reversal symmetries are broken. I will also discuss how some of these ideas can be applied profitably to two-dimensional models.

Wednesday 25

Didier Poilblanc

TBA

Erez Berg

TBA

Thursday 26

Alexander Altland

Quantum criticality of the topological Anderson insulator

In the presence of even weak amounts of disorder, low dimensional topological band insulators turn into topological Anderson insulators (tAI). Translational invariance being absent, the tAI must be described by concepts different from the clean limit band structures classification schemes. In this talk we argue that much of the universal physics of the tAI is contained in the system size dependent flow of two parameters, the first of which is an average transport coefficient (at any finite size, the tAI is a conductor), and the second the mean value of a now statistically distributed topological index. These two parameters exhibit flow similar to that of the Pruisken-Khmelnitskii flow diagram of the quantum Hall insulator. Specifically, the flow describes describes quantum criticality at topological phase transitions, the approach towards an insulating configuration away from criticality, and, along with it, the emergenece of a self averaging integer index. For some symmetry classes, that flow can be established in closed analytic form. However, we argue that the overall picture is of more general validity and provides a unified framework to describe both the bulk and the surface physics of the topological Anderson insulator.

Michail Lukin

TBA