Abstracts for CONDMAT 2017

Monday, May 22, 2017

09:00 David Schuster
09:45 Julia Meyer
Non-equilibrium quasi-particles in disordered superconductors

Experimentally, the concentration of quasiparticles in gapped superconductors always largely exceeds the equilibrium one at low temperatures. Since these quasiparticles are detrimental for many applications, it is important to understand the origin of the excess. We demonstrate that the dynamics of quasiparticles localized at spatial fluctuations of the gap edge becomes exponentially slow. This may give rise to the observed excess quasiparticles in the presence of a vanishingly weak nonequilibrium agent.

10:30 Discussions/Coffee Break @ Auditorium B
11:45 Andy Mackenzie
Physics opportunities in ultra-pure delafossite oxide metals

I will describe my group's research on a relatively little-studied but intriguing family of metals, the delafossite series of layered oxides.
For reasons that are not perfectly understood, these materials have amazingly high electrical conductivity, with mean free paths of hundreds of angstroms (longer than even elemental copper or silver) at room temperature, growing to tens of microns at low temperatures. We are interested in them as possible hosts for hydrodynamic electronic transport, and investigate this by fabricating size-restricted microstructures using focused ion beam techniques. As layered materials that can be cleaved at low temperatures, they are also well suited to study by angle resolved photoemission spectroscopy, and host a variety of interesting surface states in addition to a simple single-band bulk electronic structure. If time permits I will discuss our findings on non-magnetic PdCoO2, PtCoO2 and PdRhO2 and magnetic PdCrO2.

12:30 Lunch @ Auditorium B
13:45 Archive Tour @ Auditorium A
14:30 Xie Chen
Matrix Product Representation of Locality Preserving Unitaries

The matrix product representation provides a useful formalism to study not only entangled states, but also entangled operators in one dimension. In this talk, I will consider unitary transformations and show that matrix product operators that are unitary provides a necessary and sufficient representation of 1D unitaries that preserve locality. That is, I will show that matrix product operators that are unitary are guaranteed to preserve locality by mapping local operators to local operators while at the same time all locality preserving unitaries can be represented in a matrix product way. Moreover, we find that the matrix product representation gives a straight-forward way to extract the GNVW index for classifying 1D locality preserving unitaries. The key to our discussion is a set of `fixed point' conditions which characterize the form of the matrix product unitary operators after blocking sites. Finally, I will show that if the unitary condition is relaxed and only required for certain system sizes, the matrix product operator formalism allows more possibilities than locality preserving unitaries. In particular, I will give an example of a simple matrix product operator which is unitary only for odd system sizes, does not preserve locality and carries a `fractional' index as compared to their locality preserving counterparts.

15:15 Discussions/Coffee Break @ Auditorium B
16:15 Dmytro Pesin
Kinetic orbital moments and nonlocal transport in disordered metals with nontrivial band geometry

Tuesday, May 23, 2017

09:00 Frank Pollmann

Dynamical signatures of quantum spin liquids

Condensed matter is found in a variety of phases, the vast majority of which are characterized in terms of symmetry breaking. However, the last few decades have yielded a plethora of theoretically proposed quantum phases of matter which fall outside this paradigm. Recent focus lies on the search for concrete realizations of quantum spin liquids. These are notoriously difficult to identify experimentally because of the lack of local order parameters. In my talk, I will discuss universal properties found in dynamical response functions that are useful to characterize these exotic states of matter.

First, we show that the anyonic statistics of fractionalized excitations display characteristic signatures in threshold spectroscopic measurements. The low energy onset of associated correlation functions near the threshold show universal behavior depending on the statistics of the anyons. This explains some recent theoretical results in spin systems and also provides a route towards detecting statistics in experiments such as neutron scattering and tunneling spectroscopy [1].

Second, we introduce a matrix-product state based method to efficiently obtain dynamical response functions for two-dimensional microscopic Hamiltonians, which we apply to different phases of the Kitaev-Heisenberg model. We find significant broad high energy features beyond spin-wave theory even in the ordered phases proximate to spin liquids. This includes the phase with zig-zag order of the type observed in α-$RuCl_3$, where we find high energy features like those seen in inelastic neutron scattering experiments.

[1] S. C. Morampudi, A. M. Turner, F. Pollmann, and F. Wilczek, arXiv:1608.05700.
[2] M. Gohlke, R. Verresen, R. Moessner, and and F. Pollmann, arXiv:1701.04678.

09:45 Shahal Ilani

Imaging the Quantum Wigner Crystal of Electrons in One-Dimension

The quantum crystal of electrons, predicted more than eighty years ago by Eugene Wigner, is still one of the most elusive states of matter. Experiments have searched for its existence primarily via measurements of macroscopic properties, but since these resemble those of non-interacting electrons, a clear-cut observation of this crystal is still lacking. In this talk, I will present our recent experiments that observe the one-dimensional Wigner crystal directly, by imaging its charge density in real space. To measure this fragile state without perturbing it, we developed a new scanning probe platform that utilizes a pristine carbon nanotube as a scanning charge detector to image, with minimal invasiveness, the many-body electronic density within another nanotube. The imaged density looks utterly different than that predicted by single-particle physics, but matches nicely that of a strongly interacting crystal, in which the electrons are ordered like pearls on a neckless. The quantum nature of the crystal emerges when we explore its tunneling through a potential barrier. Whereas for non-interacting electrons only a single electron should tunnel across the barrier, images of the density change upon tunneling show that in our system a small crystal tunnels collectively, involving the motion of multiple electrons. These experiments provide the long-sought proof for the existence of the electronic Wigner crystal, and open the way for studying even more fragile interacting states of matter by imaging their many-body density in real space.

10:30 Discussions/Coffee Break @ Auditorium B
11:45 Roni Ilan
12:30 Workshop photo outside
12:40 Lunch @ Auditorium B
14:00 Maria Hermanns

Kitaev spin liquids — from topological order to material synthesis

The Kitaev honeycomb model is arguably one of the most influential examples of a topologically ordered phase of matter. At the heart of the this model are the Kitaev interactions, which are anisotropic Ising-like interactions, for which the exchange easy axis depends on the bond direction. It is one of the few highly frustrated spin models that is exactly solvable and, thus, has shaped our understanding of quantum spin liquid phases in general. In recent years, it has been shown that Kitaev interactions occur naturally in certain transition metal compounds, which are commonly referred to as Kitaev materials. An important hallmark of these systems is the surprising variety of quantum spin liquids that can be realized — in particular in three spatial dimensions.
The richness of the theoretical model combined with recent breakthroughs in material synthesis have lead to a rapidly growing field which is marked by the strong interplay of theory and experiment, aimed at identifying signatures of topological order not just in ground state properties but also in the properties of excited states.

14:45 Jens Bardarsson

Natural orbital occupations in many-body localized eigenstates and dynamics

The emergent integrability of the many-body localized phase can be understood in terms of localized quasiparticles. As a result, the occupations of the one-particle density matrix in eigenstates show a Fermi-liquid like discontinuity. Furthermore, in the steady state reached at long times after a global quench from a perfect density wave state, this occupation discontinuity is absent but the full occupation function remains strongly nonthermal. We discuss how one can understand this as a consequence of the local structure of the density wave and the resulting partial occupation of quasiparticles. Phenomenologically, this is reminiscent of the effect of temperature in Fermi liquids that results in smearing of the occupation function.

15:30 Discussions/Coffee Break @ Auditorium B
16:30 Dmitry Abanin

Wednesday, May 24, 2017

09:00 Michael Kohl

09:45 Jonathan Keeling

Quantum Many-Body Physics with Multimode Cavity QED

By placing cold atoms in multimode optical cavities, one can engineer classes of Hamiltonians and forms of dissipation that enable one to access novel states of non-equilibrium matter. This experimental system combines quantum optics and ultracold atomic physics with the quantum many-body physics traditionally explored in condensed matter physics. In this talk, I will discuss the possibilities that arise from this system. In particular, I will discuss the experiments [1,2] where such a system has been realised, and how these have been used to demonstrate the potential of multimode cavity QED to engineer interactions with controllable range.

Based on these experimental capabilities, I will then discuss our theoretical work beginning to exploit the potential offered by these experiments. I will discuss how a multimode cavity can be used to engineer a synthetic gauge field, in such a way that the synthetic field responds to the state of the atoms. Using this, we have shown how one may realise a Meissner-like effect for ultracold atoms[3].

If time allows, I will then discuss aspects of how a Hopfield associative memory can be realised in such a system [4], and discuss our recent work developing the microscopic theory of this behaviour.

[This work has been done in collaboration with K. Ballantine (University of St Andrews), V. Vaidya, Y. Guo, A. Kollar, J. Cotler, S. Ganguili and B. Lev (Stanford).]

[1] A. J. Kollar, A. T. Papageorge, K. Baumann, M. A. Armen, and B. L. Lev, New J. Phys. 17, 043012 (2015).
[2] A. J. Kollar, A. T. Papageorge, V. D. Vaidya, Y. Guo, J. Keeling, and B. L. Lev, Nat. Commun. 8 14386 (2017)
[3] K. E. Ballantine, B. L. Lev, and J. Keeling, Phys. Rev. Lett. 118, 045302 (2017).
[4] S. Gopalakrishnan, B. L. Lev, and P. M. Goldbart, Phys. Rev. Lett. 107, 277201 (2011).

10:30 Discussions/Coffee Break @ Auditorium B

11:45 Corinna Kollath

Dissipative dynamics in ultracold atoms

Atomic gases cooled to Nanokelvin temperatures are a new exciting tool to study a broad range of quantum phenomena. In particular, an outstanding and rapid control over the fundamental parameters, such as interaction strength, spin composition, and dimensionality allows to realize and observe many different situations far from equilibrium. Long-standing questions such as the coupling to an environment can be investigated. In my talk, I will address the question of the influence of a coupling to an environment on the system dynamics in optical lattice gases. The interplay between the interaction, the kinetic energy and the coupling to the environment causes a critical dynamics with algebraic decaying observable or diffusive behaviour in the formation of correlations.The coupling to a cavity can lead to dynamic formation of a gauge field causing topologically non-trivial quantum phases.

12:30 Lunch @ Auditorium B

14:00 Gunter Stolz

Many-body localization of the droplet spectrum in the random XXZ spin chain

We report on recent joint work with A. Elgart and A. Klein in which we study many-body localization properties of the disordered XXZ spin chain in the Ising phase. Disorder is introduced via a random magnetic field in the z-direction. We rigorously prove a strong form of exponential clustering for eigenstates in the droplet spectrum: For any pair of local observables separated by a distance D, the sum of the associated correlators over these states decays exponentially in D, in expectation. Our result applies to the large disorder regime as well as to the strong Ising phase at fixed disorder, with bounds independent of the support of the observables.

14:40 Wojcieh de Roeck

15:30 Discussions/Coffee Break @ Auditorium B

16:30 Netanel Lindner

17:15 Wrap-Up